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BY

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AUTHOR OF
"TRAINING IN FOREMANSHIP AND MANAGEMENT"
"FOUNDRY ORGANIZATION AND MANAGEMENT"
THE PRINCIPLES OF RATIONAL INDUSTRIAL MANAGEMENT

WITH A FOREWORD BY

DAVID BROWN

MANAGING DIRECTOR
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FOREWORD

By David Brown, *Managing Director, Messrs. David Brown & Sons (Huddersfield) Ltd.*

If you were to ask me what is the most important factor in business, I would suggest it is wisdom in those who have the privilege of managing business. Not intelligence merely, not knowledge of business method, but rather the ability effectively to apply intelligence and knowledge to the business situation. You will agree that there is little virtue in high intelligence or in profound knowledge; the virtue of these springs from their right application. Management may be highly intelligent, may know all the modern techniques of organization, but if it has not the capacity rightly to apply these, then, indeed, ineffectiveness will result.

I have heard it said that management is a science, I have also heard management called an art; my opinion is that good management is the art of applying scientific knowledge (and common sense) to the business situation so that business is at once economically effective and socially useful.

Our business, a typical engineering one, has demonstrated the truth of the foregoing during the seventy-nine years of its existence. Our primary investment has been in men of right experience and right knowledge with, above all, the ability to use that experience and knowledge in a rational manner. Around these men our organization has developed.

You will notice that Mr. Gillespie's book, although it deals largely with engineering methods, stresses the virtues of personal worth; more, it stresses the virtue of personal

worth in a group setting. This attitude, one that Mr. Gillespie carries into his work, makes all the more valuable what he has to say of methods of reorganization. I think that anyone with a ready pen and a good library could write a passable book on organization in these days; but to write on engineering reorganization, and especially on general engineering reorganization, requires courage and intense experience of our industry. Mr. Gillespie, I need hardly say, shows these qualities in this book.

PREFACE TO THE SECOND EDITION

FOR criticism and appreciation of the first edition I am grateful to Weston Howard, of Hayward Tyler, Ltd., T. Tanner, of Birmingham Electric Furnaces, Ltd., John Sagar, of Sagars, Ltd., A. Pike, of G. A. Harveys (London), Ltd., and M. Sigmund, of Sigmund Pumps, Ltd. In the light of the comments I have had from these gentlemen and from reviewers I have made a number of alterations and additions to the earlier printing.

J.J.G.

AUTHOR'S PREFACE

THIS book is written for small and large engineering companies *not* engaged on continuous or mass production. In it I have tried to put the results of nearly eleven years' experience of reorganizing and advisory work with engineering companies employing from fifty to 2000 people.

The chapters on mechanics of quality control, planned inspection, planned maintenance, the drawing office, the laboratory, casehardening, plating, forging and like department analysis, and the human relations graphs will, I hope, interest the reader as fresh angles of approach to uncharted subjects; I would also draw earnest attention to the chapters on costing, financial control, and selling. If I seem at times to hit out over-hard at management scientifics and soporifics, I plead the right to a spot of fun.

Six articles on "Engineering Works Reorganization" published in *Engineering*, followed by the disposal of

1000 reprints, gave rise to this book—a four-times multiple of the original articles. I thank Major Cowan, Editor of *Engineering*, for permission to use already published material. From Mr. J. Whalley with Chapter IX and from Mr. A. D. Worton with Chapters XXIV and XXV I had valuable assistance.

The foregoing is the all too scant sum of my named acknowledgments; the truth is that almost every foreman and manager I have met in work has either added to the extent of my knowledge or has subtracted from the extent of my foolishness.

To end, although I criticize engineering organization I do not therefore criticize engineering. I am an engineer, and when I consider the worth of this effort against the background of past and present engineering technical accomplishments I know afresh that the real values in engineering are not those contributed by people like myself, but are those of the less vocal and seldom-sung manipulators of slide-rules and chisel-pointed pencils; however, here is the book.

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FROM

F.E.G., I.D.G., A.N.G., AND J.J.G.

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CHAPTER I

METHODS OF APPROACH

ALTHOUGH we here stress the value of Scientific Method, it must be clearly understood that the most important factors in management are personal character and ability. Method in the hands of a rogue will increase roguery, in the hands of a fool will increase foolishness, and in the hands of self-seekers will increase exploitation.

Thus, we look upon Method as a valuable tool when rightly used for a right objective.

DEFINITION OF METHOD

Inductive or scientific method is a logical mode of arriving at general propositions by systematic observation and examination of particular facts. To state a case in point: when a question of the effectiveness of a machine tool arises, we could collect facts on (*a*) accuracy of operation, (*b*) speed of operation, (*c*) ease of operation, (*d*) amount of labour effort necessary for operation, (*e*) power cost per unit produced or per hour, (*f*) depreciation cost as (*e*), (*g*) rent cost as (*e*), etc.; from the study of these facts we could fairly conclude whether or not the machine is effective as compared with other machines the purpose of which is similar—this, broadly, is inductive method.

PRINCIPLES OF METHOD

The following principles, from the writer's *Principles of Rational Industrial Management*[1] outline in fair detail the methodical process. Behind the principles lie two generally accepted axioms—(1) causality: every effect in business is the result of a cause; (2) uniformity of nature: any non-free cause which produces a given effect in one instance will produce the same effect in similar instances.

Inquiry Objective. The objective of any inquiry into a business problem must be clearly and definitely stated so that time and effort may be a minimum and results a maximum.

Problem Definition. The problem to be solved must be stated exactly, all obscure terms must be eliminated, and the problem divided into its constituent parts to avoid waste of time or effort on obvious points, straying from the objective, and to assist precision of purpose.

Logical Procedure. The logical procedure should be pursued to the exclusion of any investigations which do not contribute directly to the objective; it should commence at the logical beginning, and it should be such that each successive step is supported by observed facts.

Principle of Procedure Limitations. The limiting influences peculiar to the inquiry should be determined and consideration given to the effect on the inquiry of such factors as (*a*) permitted expenditure of time and money, (*b*) method of fact collection that may be used, (*c*) help available, (*d*) the relation of the business policy to inquiry development.

Right Experience. The person carrying out the inquiry should have sufficient definite knowledge of the subject under investigation to avoid fallacies arising from mal-observation.

[1] Published by Sir Isaac Pitman & Sons, Ltd.

Right Observation. Observation for the facts of the problem should be free from bias and prejudice.

Analysis. The whole field of the problem should be analysed to its elements so that every fact bearing on the problem will be clearly observed.

Identification. Each fact in the inquiry should be clearly identified in terms of inquiry objective.

Unit of Measurement. The facts must be stated in a unit which is clear and definite in meaning and is consistent within the class to which the facts belong.

Classification. The facts should be systematically arranged under the logical divisions set out when the problem was first defined or under such logical divisions as appear necessary, so that complete understanding of all the facts in relation to inquiry objective is made possible and good judgment is encouraged (see page 32).

Reference to Class and Law. The classified facts should be referred to a known class or series of facts or to known laws for explanation.

The Hypothesis. If the facts cannot be referred to a known series or to known laws, any hypothesis drawn from the facts should be verified by the use of recording instruments if it can be so verified, by comparing and/or contrasting with like and unlike instances, or by experiment.

Experiment. Where it is at all possible and economical, the hypothesis should be tested by arrangement of conditions as required by the hypothesis to discover if results are as indicated by the hypothesis.

INVESTIGATION BEFORE REORGANIZATION

The organizing procedure to be used in any company will depend on numerous factors, each of which may require investigating, and the mechanisms and systems to be installed can properly be designed only in the light of

factual knowledge about what is needed, if these are economical, and if they are workable for the particular company.

The foregoing is strikingly borne out in the strikes and disputes following on the efforts of what Diemer[1] calls "companies of the high-pressure exploitation type" to introduce ready-made techniques into British engineering companies. It was argued that similar companies abroad had successfully used these techniques, but the dissimilarity which was not investigated was the psychology of typical groups of British engineers.

ENGINEERING PROCEDURE

The engineering approach to reorganization will not be concerned with time or labour study, with planning or with chart controls. It will, as far as is possible, follow the principles of method, and, even if at the investigatory stage a start may have to be made at some point other than at the beginning, method will be applied at this point, and a return to the beginning will be made as soon as is possible.

Only when the engineer is satisfied with fundamental measurement and quality control will he move to material control and tool control; when these are reasonably correct he may then go on to processing, ratefixing, planning, and progressing. Common sense will tell the trained engineer that if quality control is not right, fitting times will vary above effective level; if material control and tool control are not right, rates in the machine shops will be excessive and planning poor; if processing is not right, progressing will be based on inquests on customers' delivery dates.

The engineering method is sure and patient, and, at the end, a sound job of work is done; indeed, it is the only method which will guarantee that result.

[1] *Factory Organization and Administration* (McGraw-Hill).

PRINCIPLE OF NEW TECHNIQUE APPLICATION

It is true, despite the claims made to the contrary by scientific managers, that scientific method is not a guide to analysis and measuring of biological and social phenomena, and that scientific method may or may not produce sound conclusions (this depends on the experience and intelligence of the user of the method); but, in either event, the conclusions require practical application. To the principles of method we may add one dictated by common sense—

If decisions on new codes and procedures arising from the application of logical method to business affect the human factor, they should be so applied that they fit into group psychological structure.[1]

The foregoing principle gives a clue to why certain high-pressure schemes of reorganizing are acquiesced in by girls and unskilled labour in toffee, boot and shoe, textile, and other businesses, but in the engineering and founding trades are turned down unreservedly by skilled groups of people.

Management should use scientific method where it can, but that will not make management scientific. Management personality and character vitalize all of the tools it uses, and on management personality and character largely depends the success or otherwise of new technique application to human groups. Thus, it is insisted throughout this book that while the value of scientific method and other tools is granted, these, and the results of their use, are of negative value if the experience, integrity, skill, and general character of the management be not of a high order.

[1] *Principles of Rational Industrial Management*, Gillespie (Pitman).

CHAPTER II

QUALITY AND QUANTITY OF MANAGEMENT

By management is not meant the use of scientific method, codified knowledge, time study, costing, planning, nor, indeed, the use of any tools in the service of management purpose: management will be management, whether or not it uses any, all, or none of these. To us, *industrial management is a form of personal conduct, the effectiveness of which is dependent on the interplay of the situation to be managed with the physical, moral, mental, and emotional characteristics which the manager brings to the service of industrial effectiveness.*

Management is no more and no less than that. Management's task is effectively to guide human effort in an organized, controlled application to material production and distribution in the service of social wants, so that, at least, the values produced will be no less than the values consumed in the producing and distributing process. Included in these values is the value of the service of shareholders, the return for which is profit.

MANAGEMENT AUTHORITY ANALYSIS

We could start by getting out a management organization chart showing each executive official's position and asking—

1. Is there one person with full authority over all special (departmental) managers?

2. Is there interference by directors, i.e. do directors give orders or receive reports from persons responsible to the general manager? (In many organizations this is a fertile source of trouble; worst of all, one finds directors cutting across general management with the object of playing one person against another and so "finding out things." In some instances, a director will be a head progress clerk and

keep everyone on the jump by chasing this order, then that order, to the exclusion of all else.)

3. How many people are directly responsible to the general manager and report to him? (If more than five or six, consider if re-allocation of functions is necessary.)

4. How many people have each of the sales, office, technical, works, and production managers reporting direct to them?

5. Is there any interference from general management with the running of the sales, office, works, and other departments, i.e. does the general manager go over his managers' heads with orders or for reports?

6. Is there cross-interference among departmental managers? (We shall have more to say of this and like matters later.)

7. How many people has each of the foremen working for him? (In general engineering where there is functionalized full processing and planning, functionalized inspection, costing, maintenance, and employment, the figure may go up to 35, depending on work complexity and accuracy.)

8. Is there interference with the foreman's authority by upper management?

MANAGEMENT FUNCTION ANALYSIS

Too often one finds a general manager up to his ears in late-delivery matters and general business detail—this in quite big companies. The fault often lies in failure to delegate authority, and sometimes in wrong management organization. Somewhat similar faults may be found at most other management levels.

1. Has the general manager an organized system of reports covering, at defined periods, the financial situation, costing results, output and sales situations, and customer complaints—these presented in condensed form, duly compared with previous period figures, once each month? (It

is realized that in the company employing, say, about a hundred people, personal contact will effectively take the place of numerous reports; financial and costing reports are, however, likely to be necessary.)

2. Are authority and responsibility for each of the company's chief activities properly delegated?

3. Is the works manager burdened with control of planning, progressing, ratefixing, material control, inspection, and functions other than that of preserving balanced operation? (It is openly admitted, as is shown later in this chapter, that often enough the organization has to be moulded to the available staff rather than to academic considerations. On the other hand, when a general engineering company gets to the stage of employing, say, 200 people, there should be distinct inspection, planning and progressing, and ratefixing functions, and the first, at least, should be away from works control—subject to the proviso in the previous sentence.)

4. Has each major departmental executive a properly organized report system covering the major factors in his department?

5. In the moderate- and larger-size companies, at least, are repetition activities covered by standing orders as to procedure, and are orders affecting producing in any of its aspects put in writing? (This refers to changes in policy, to design departures from accepted method, orders to carry out work, and the like; it does not refer to the ordinary face-to-face instructions which are usual with normal proceedings.)

MANAGEMENT PERSONAL ANALYSIS

The author, to be frank, pays less and less attention to method and system and more to people's attitudes and what they are prepared to be and do as his experience increases.

Indeed, *by putting management attitude right, by giving it a chance and showing it how, the correction of wrong activity will follow.*

The selling of systems and stop-watch techniques for large fees cuts across the foregoing principle, yet, in fact, the average foreman or works manager could do much better than the system sellers, and with less trouble, if a chance were given to learn and to try. The writer has proved this in scores of instances, and in a number of these after the high-pressure type of organizer had failed.

1. Do the top executive officials set an example of courtesy and sincerity to those subordinate to them?

2. Does each top executive official make it his business to know the interests and attitudes of those working immediately for and with him?

3. Do executive officials have the attitude of making their people *want* to do things, not *making* them do things?

Recently, I was with a company which had to increase its output 25 per cent with no increase in worker hours. We got 20 per cent increase with 7 per cent less labour, but records proved that operator response was not very good, and observation showed there was a tense, neurotic atmosphere spreading from the top downwards—criticism and grumbling were the rule and encouragement was sadly lacking. This was faced up to by the two people responsible and a weekly encouragement tour of the operators was started. It sounds incredible, but it is on record that operator hourly output increased a further 15 per cent. True, the product was not very complex and most operations were manual, but the lesson is true of business and of all human effort—

Each one of us wants to be wanted, and just as you, reader, respond to interest and encouragement, so will your people in work.

MANAGEMENT RELATIONS

For some years the writer has made a study of managing and operating group relationships, but has found difficulty in charting the results. Unfortunately there has as yet been little work done by sociologists on group relationships, and what has been done has not successfully been charted. Fig. 1 is a rather inadequate managing relations chart, and Fig. 61 (page 207) is a managing-operator group relations chart which may interest the reader.

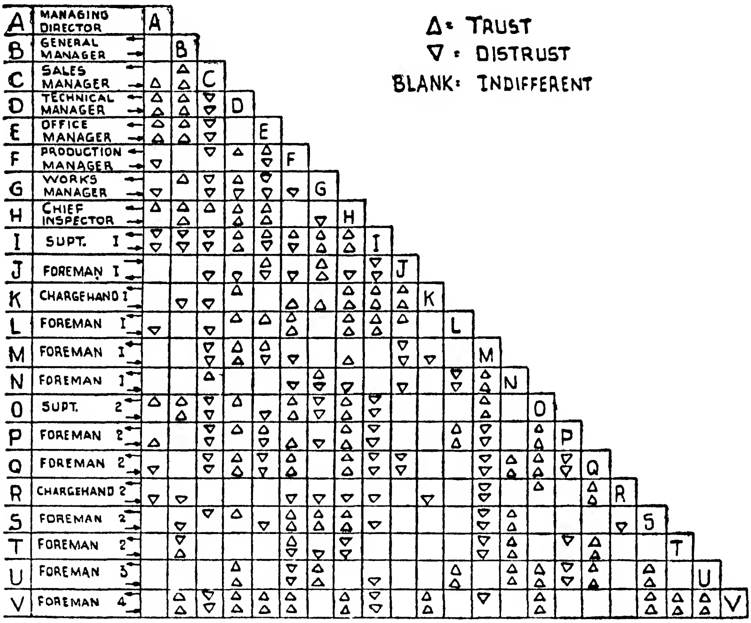


FIG. 1. MANAGING GROUP RELATIONS CHART

The charts are simple to read. Thus, the arrow pointing towards the Sales Manager shows that A is indifferent towards him and B trusts him, while the Sales Manager trusts both A and B. The Technical Manager is distrusted by C (the Sales Manager) and gives distrust in return.

When we come to analyse the individual and co-operating characteristics of any person, it should firmly be realized that *the most important thing is not that a man should run his own department well, but that he should run it so that it is a frictionless part of the whole business machine. Too often one finds an executive official sacrificing other people to his own anxiety or to his desire to shine, and other departments for the sake of his own department. Than this there is nothing more likely to kill the spirit of a business team.*

A good team need not be made of equally strong men so long as each man in that team has a certain strength to add to the strength of the whole and can be trusted by his team-mates.

Any analysis, then, of business effectiveness should study management relationships, for these are of first importance.

MANAGEMENT GROUP INTEGRATION

The management charts (Figs. 2 and 3) beloved of theorists may be a snare and a delusion to the student of management. The lines of these charts show the upward and downward flow of authority and responsibility, and the horizontal relationships of people on the same plane of activity. But they delude the student into thinking that co-ordinated relationships stated in place and time are in importance equal to or greater than the particular and general co-operativeness of each person in the management organization to each other person.

Fig. 1, as we have seen, is a chart showing the integral relationship of an actual management organization; when this chart of integral relationships was first incorporated in a report, both the managing director and the general manager were mixed in their reception of it. Later, a mutual-trust drive was started, and, after two changes had been

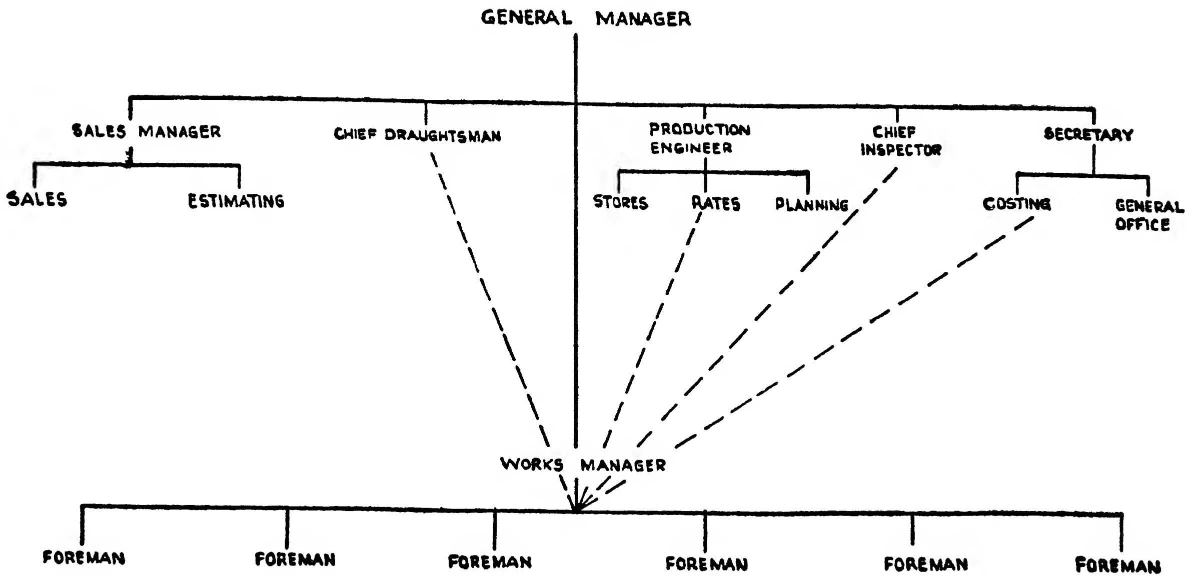


Fig. 2 Organization Chart of 250-Employee Company

made, the whole organization brightened up and showed astonishing vitality, both in the way of new ideas and mutual protection in trouble.

The major faults were—

(*a*) General manager inclined to listen to complaints from one chief executive about the other chief executives—called "pulling fast ones."

(*b*) Managing director appeared from office only occasionally, then ignored nearly everyone—"high hat."

(*c*) Works manager blamed production engineer for this and that. Works manager had favourites among foremen and showed bias towards one of two superintendents; this superintendent supposed by foremen and other superintendent to be "a bit of a yes-man."

(*d*) Foremen generally decent fellows, but one or two tale-bearers among them.

(*e*) The higher grades of authority did not get together enough, nor did they get together with the foremen.

(*f*) Works management group as a whole thought they were being bluffed by false monthly figures (one of the curses of management bonuses) when, in fact, they were not.

(*g*) Works manager inclined to go over superintendents' heads with orders to foremen.

The managing group should be a rational group of the direct contact type, with, as common stimulus, the realization of company policy. In terms of co-ordination there will (Fig. 2) be top, middle, and lower groups within the management organization, but, in terms of integration, there should be one whole team within which each unit plays its fitting part in a balanced whole: this, ideal of ideals, should extend over the whole organization.

MANAGEMENT UTILIZATION

When one analyses the utilization of management ability, some interesting data arise from the study.

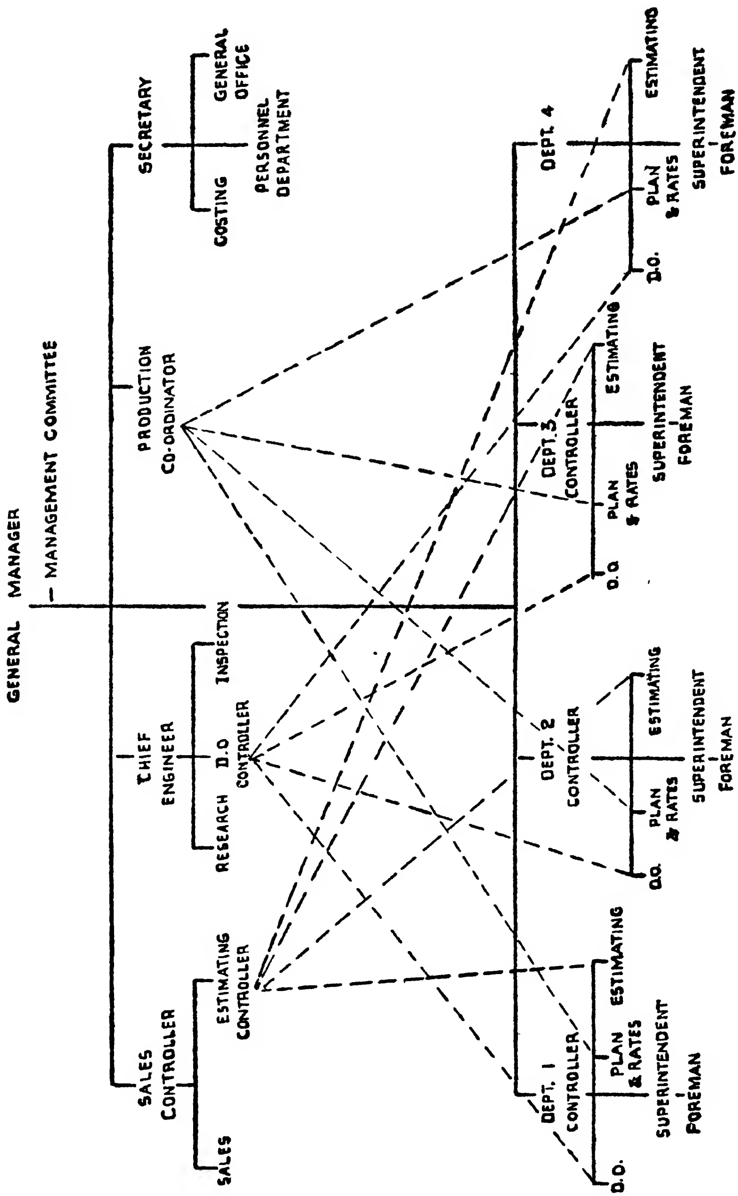
It is true that utilization of effort is greatest when the effort is concentrated in one special direction; but it is also true that, in general, specialization should increase only as the quantity of things to be done or the content of activity increases. Thus, in the engineering company employing 20 people, we may expect to find a foreman or chargehand planning work, progressing work, fixing rates, hiring and firing men, handling stores, and so on, and perhaps one other person looking after sales, finance, and the general run of the business. But in a company employing 2000 people we expect to find specialist labour on specialist tasks, both on the operating and the managing sides of the business.

WORKS MANAGER'S TIME ANALYSIS

Here is a general analysis of a works manager's time for one day—

Morning	minutes
Executive daily conference	60
Trouble letters	25
Follow up trouble letters	95
Phone calls	10
See technical departments	30
See three foremen—general work	20
Afternoon	
Follow up trouble letters	45
Report to general manager on above	25
See buyer	15
Phones	15
Cup of tea	10
In weld shop (advice)	40
Stores after material	25
See maintenance engineer	20
Reply to letters	40
Trouble letters	30
Odd interviews in office	25

The company had in the works about 300 people, and the works manager was in charge of eight foremen, planning, progressing, stores, maintenance, and tool-room. It was


GENERAL MANAGER
— MANAGEMENT COMMITTEE
SECRETARY
COSTING
PERSONNEL DEPARTMENT
GENERAL OFFICE
PRODUCTION CO-ORDINATOR
CHIEF ENGINEER
RESEARCH
D.O CONTROLLER
INSPECTION
SALES CONTROLLER
SALES
ESTIMATING CONTROLLER
DEPT. 1 CONTROLLER
DEPT. 2 CONTROLLER
DEPT. 3 CONTROLLER
DEPT. 4
D.O.
PLAN & RATES
ESTIMATING
SUPERINTENDENT
FOREMAN

impossible to organize effectively on the old basis, and planning, progressing, and stores were functionalized away from the works manager and put in charge of a production engineer directly responsible to the general manager.

FOREMAN'S TIME ANALYSIS

In many shops a somewhat similar state of affairs will be found if any of the grades of management be analysed. Indeed, the average luckless executive official is usually burdened with tasks, and before he has time to finish one, another is thrust upon him. Foremen, for example, are usually the bearers of all sorts of burdens. On an average of 14 foremen whose tasks were recently analysed by the writer, the following resulted—

	per cent
Time spent with operators	20
Answering phones and clerical work . .	20
Work-chasing	40
In drawing office and other departments .	20

Such analyses as the foregoing (made either by using special log sheets or by actual observation by an analyst) are usually fruitful. Special attention should be paid to number of people controlled.

MANAGEMENT CO-ORDINATION

The principle of co-ordinating structure is—

As specialization increases, the need increases for a formal structure which will effectively link up all of the specialist activities with the supreme authority, will effectively make contact between methods specialists and operating group leaders (vertical structure), and will make effective the collaboration of groups at their own and at other levels (horizontal structure).[1]

The chart shown in Fig. 2 illustrates the management organization of an engineering company employing 250 people; the larger company may functionalize personnel

[1] *Principles of Rational Industrial Management*, Gillespie (Pitman).

work and research, and, too, may have a general works council with management and men represented. The company employing 1000 people or more in the making of different products may decentralize drawing office, estimating, planning, rates, and sales (Fig. 3) for one or more of these products and have a controller in charge of each product with a superintendent in charge of production. This is contrary to theory, but is very workable.

It is worth making out an extensive organization chart showing all management relationships from the general manager down to chargehands and tool-setters, entering the number each of male skilled, semi-skilled, and unskilled personnel controlled, and female personnel and apprentices. The most recent case in which this was done for the writer showed bad distribution of authority and responsibility, uneven payment, and, surprisingly, that although one shop had the recognized quota of apprentices to skilled people, not one other shop had the quota. In the worst-showing shop in this respect there was one apprentice to 28 skilled men—because the foreman did not like apprentices.

CHAPTER III

THE IDEA OF CENTRAL PLANNING

WORKS about planning systems, and goodness knows there are plenty, are not planning, and while it is agreed that the pretty systems seen on paper are not of much use to practical engineers, it should be recognized that the development of central planning is not just somebody's notion, but is an expression of an economic law[1]—that of specialization.

WHY PLAN AT ALL?

We all plan in some fashion or other. For example, we say, "This job is due on *x* date, so it should be started about *y* date"—this is planning. If there were only a few jobs to be done, this kind of planning might work; but if there were many jobs to be done and each job had numerous parts, we would have to consider the problem a lot more and it would pay to have someone do the considering for us and do nothing else. There we stumble on the law of specialization—

Concentration of effort on a limited field of endeavour increases quality and quantity of work done.

Put it this way. If material has to be controlled in terms of deliveries of orders, if jobs have to be started so that parts will come together in the right place and at the right time, scrap replacements and part alterations have to be looked after, every operation has to be done on the correct machine in the correct manner, and if work has to be kept moving so that capital sunk in work in progress will be a minimum, is it better to plan in advance to cover these points, and to have trained people doing the planning? In other words, is it or is it not better to prepare in advance as

[1] This economic law of specialization is, in fact, the biopsychological law of differentiation.

far as it is possible to do so, and is concentration of effort on a limited field better than dissemination of effort over many fields?

The writer knows not one but dozens of engineering executive officials who would, in effect, answer that unprepared, disseminated effort is best. They accept specialization of effort on book-keeping, costing, drawing, estimating, and inspection, but do not accept it on planning nor, sometimes, on ratefixing.

On the other hand, some executive officials have been sickened of the word "planning" by would-be planning experts trying their hand at the institution of this or that planning system they have evolved, have read about, or have seen working somewhere else. Others feel that planning as written about is too involved for their size of works or their multiplicity of products.

PLANNING ACCORDING TO THE BOOK

Recently the writer was in contact with a company of elevating engineers, the general manager of which is very intelligent. This official has a fine library of books on administration and organization, and, so he stated, he had considered from these books more than two score planning systems and had tried out four, none of which worked.

The books took it for granted that a lot of 500 to 10,000 shafts going through a shop was the normal thing, when, in fact, a batch of 100 for this shop was extraordinarily good.

Yet a more recent case was of a company of transmission engineers, employing about 1500 people. Two experts had tried their hands at installing planning systems and failed, because they too had the 500–10,000 batch of similar products in mind.

One man spent three months getting out little tickets for each operation in the shop, and one week-end mounted the tickets (thousands of them) in operation sequence on a huge

progress board. On the following Wednesday there was complete chaos in the shops, and for about two years afterwards anyone who mentioned planning was running severe physical risks!

WHAT PLANNING REALLY DOES

If the engineer executive official planned in advance for the product—

(*a*) What should be done (product planning)
(*b*) How it should be done (process planning)
(*c*) When it should be done (schedule planning)
(*d*) Where it should be done (production planning)
(*e*) Cost of doing it (ratefixing)

and finally set up controls to

(*f*) Ensure the job is done as planned for both time and place (progress control),

he would have a full planning system. But, despite books to the contrary, the shops which can have full-scale planning as outlined above are in the minority, and for very good reasons.

HOW MUCH PLANNING?

We have stated the law of specialization (page 18), but there is a limit to its application; for, in general, *as quantity of similar things to be done increases, so can specialization economically increase.*

Thus, the amount of specialized planning will depend on the quantity of similar things to be done. The amount of planning in a "one-off" shop will be very different from that in a mass-production shop; also, the amount of planning in a shop doing small batches of various products will be very different from that done in a similar shop selling larger quantities and producing larger batches of various products. We are not here concerned with mass-production or continuous shops (these, though most written about, are really

easiest to plan), and will therefore confine our attention to the general run of engineering shops.

Keeping what has been said in mind, let us refer to the accompanying table (Fig. 4), which has been drawn up from experience of the point of maximum returns from planning application. The data shown are general rather than particular, but will serve our present purpose.

Production Factors in Question	Should Planning be Used							
	One-product Works			Various Products			Small Batch and Job	Job Only
	Large Batch	Medium Batch	Small Batch	Large and Small Batches	Medium and Small Batches	Small Batch		
Detail drawings	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Parts lists and numbers	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Assembly lists and numbers	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Operation lists	Yes	Yes	Yes	Yes	Yes	Yes	On batch	?
Operation sequence	Yes	Yes	Yes	Yes	Yes	Yes	Yes	?
Machine numbers	Yes	Yes	Yes	Yes	Yes	?	?	?
Tools	Yes	Yes	Yes	On large	?Medium	No	No	No
Set-ups	Yes	Yes	Yes	On large	?Medium	No	No	No
Feeds and speeds	Yes	Yes	Yes	On large	?Medium	No	No	No
Material quantity	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Material release	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Material move	Yes	Yes	Yes	Yes	Yes	?	?	No
Inspection	Yes	Yes	Yes	Yes	Yes	Yes	?	No
Jigs and fixtures	Yes	Yes	Yes	Yes	Yes	Yes	Yes	?

Limiting factors: operation labour costs, machine rates, and job accuracy.

FIG. 4. THE SCOPE OF PLANNING

It will be noted that we have extended planning to inspection. This is as much planning as the activities usually so dubbed. We could, and shall in later chapters, extend it to sales also. After all, planning is merely intelligent forecasting, *on paper*.

CHAPTER IV

THE ORDER DEPARTMENT

It is as well to start off actual methods analysis at the order department, for from here and to here respectively do internal and external activities flow. As generally understood, the order department is associated with the sales department; in the small engineering company it is usually so. In our case we shall take the line of activity from the order department through drawing, planning, and rate-fixing to the works, returning later to sales and office aspects of order handling (Chapters XXVII and XXVIII).

ANALYSIS OF FUNCTION

Although it is usually the case that, in the small shop, sales and order department activities are merged, it is not always so. For example, the following are typical—

(*a*) Drawing office analyses all orders and issues all copy orders.

(*b*) Estimators take up orders they have quoted for and issue all copy orders.

In both of the above cases, the order was definitely a technical document and was, supplementary to the drawings, a kind of general instruction sheet, a final inspection sheet, and a final test sheet.

(*c*) Order department issues all copy orders—under control of sales department.

In the foregoing case a general order clerk and a typist producing the order in manifold were the staff. The products were highly technical, but the drawings (part, sub-assembly, and assembly) bore all technical detail.

Diemer[1] makes the order department into a kind of bridge

[1] *Factory Organization and Administration* (Mc Graw-Hill).

between the sales department and the production control department, and states that, as the order department looks after customers' needs, it should be directly under the general manager. Diemer's point of view is worth considering, but, other things apart, the average general manager has quite enough departments reporting to him without the creation of one other.

It should be a rare case indeed where the order to make products requires to be a technical instruction sheet. Where it is so, it will be found that in most cases there is a weakness in (*a*) supply of information through drawings and (*b*) supply of final test sheets. Three faults often arising from the use of a technical order are: (*a*) drawings and order may disagree in one or more details, (*b*) the words used on an order may invite different interpretations, and (*c*) it is difficult to collect and alter all copies of an order when job design is changed in process, and, in many instances, quite a number of alteration slips are used and fixed (if the foreman remembers) to the copy order with consequent confusion.

So far as order department function is concerned, it seems that this should be to verify the order as to price detail, check it against the estimate (if not for a standard product), give the order an identification number, and produce and issue order copies to the various departments. Queries as to customer's intention should go to sales and, as to technical interpretation, to design and drawing office.

ANALYSIS OF GENERAL ROUTINE

There is little use attempting to state a complete standard routine for the order department, for whilst it is both easy and commonplace to describe labour-saving machines and illustrate, say, manifold forms, the routine of the average engineering order department is tied up with the sales department, of which it is usually a part, and with the very variable routine of going through the morning's orders.

In many shops the various department heads from the works (works manager, production engineer, and, perhaps, shop superintendents) meet the sales manager, the office manager, the general manager, and the technical manager or drawing office chief, and the day's orders, inquiries, and customers' complaints are run through while the order department head takes notes.

As a "get-together" meeting this routine is useful; but if the sole object is to run through the orders and explain them, it is rather a waste of time in a large percentage of instances. The trouble with discussing complaints is that people who are not of and in the works are apt to start fresh hares running every morning, and the poor dog of a works manager may find himself chasing round in circles. If delivery complaints must be discussed, let them wait until *after* the works people have had a chance to view them in the light of *all* the work in process.

One other thing about these meetings. The "When can we deliver this order for X?" and "What delivery will we quote on this inquiry, Mr. Y?" angles require cutting out in all but small companies employing a handful of people, and perhaps in companies who deliver "from the shelf" and bring balance of finished stock records to the meeting. Load records are better than guesswork.

It is suggested that an analysis of what occurs at morning conferences be made: in one shop it was discovered that such a conference occupied each day 8 per cent of the time of seven executives at a cost of £500 per annum plus invisible losses arising from department absences.

AN EFFECTIVE ROUTINE

An effective routine is—

1. Open mail before office hours.

2. Distribute "rush" complaints and service calls at once to departments concerned.

3. Sort out orders from other remaining matter.

4. On a standard form, in triplicate, enter up each order, customer, department concerned, and value; total these and send copy to general manager's office.

5. Attach estimate and previous correspondence, if any, to order.

6. Check customer's credit standing.

All the foregoing is done by a competent clerk, and assistants as required.

7. Pass stock and standard product orders for copying and issue; pass part-replacement orders.

8. Pass "difficult" orders to drawing office or to estimating for check-up. Time-stamp these and note on form (4) where they have gone and when. These will be passed back to order department for order issue or for *filing in order department* pending replies from customers.

9. Send copy (4) to sales manager.

In a number of businesses it is rightly reckoned that "same-day" stock and servicing orders will be in the works by 9 a.m. of the day the order arrives. And why not, instead of rushing them into the works at, say, 4.30 p.m.?

PAPER ROUTINE

These are the days of billing machines for the economical production of information requiring duplication; such a machine used with continuous manifold forms will save about 30 per cent on the single-hand carbon-filled form and is suitable for companies using about fifty order forms per day.

The number of copies of each order produced will depend to some extent on the types of products produced, if they are special or stock, and, if stock, if they come "off the shelf." The minimum in most shops is—

1. One copy to territory office or to salesman.

2. One copy to general office for filing against sending of invoice.

3. One copy to planning department.
4. One copy to drawing office.
5. One copy to works manager.
6. One copy to dispatch department.
7. Original kept in sales department.

What happens to copies (4), (5), (6), and (7) will depend upon whether or not planning is centralized and how it is centralized. If it is centralized, the drawing office copy may go to planning and be released from there with a drawings release scheduled date; dispatch and other copies (including stores, if there is a stores copy) will also flow through planning. This, however, is the subject of a later chapter.

THE USE OF A TECHNICAL SALES DEPARTMENT

In many companies it would increase effectiveness to have a Sales Order department and a Works Order department. The former is usually staffed by trained technical men or women and its function is to make customer contacts about orders and to clear up technical and other difficulties. The Works Order department attached to planning makes out all needed documents for the works: works orders, route cards, job tickets and the like, and supplies works order numbers.

For companies employing, say, 900 or more people on complex products, consideration of the foregoing is suggested. It is a form of specialization which pays good dividends if rightly applied.

CHAPTER V

EFFECTIVE IDENTIFICATION

IN 99 per cent of engineering businesses a system of classification is essential. In shops where there is no classification, time and money are wasted in writing out the names of things, in tracing parts by name (it is quite possible for each department to have a special name for a certain article), in filing and finding drawings by name, in relating jigs and gauges to parts by name, in assembling parts together by name, and so on. Classification is an essential to correct procedure; without it, except in shops making very simple products with few parts, operation planning, work routing, and stores control will lack effectiveness. Hence, if there is no adequate system of classification in the works, steps should be taken to install one.

WHY THE OBVIOUSLY SENSIBLE METHOD IS IGNORED

If we consider, for example, a cast part, a drawing of the part, and the pattern for the moulding of the part, common sense will suggest that the method of identifying each of these will have a common base. Yet here is a typical identification system (or lack of system) for a cast-iron bedplate—

Part No. RU423.
Drawing No. A1743/38.
Pattern No. 6342/38.

If we go a bit farther and consider the operation on the part we have—

Part No. RU423.
First Operation No. 1.
Jig. No. J983.

If we grant "Ru" of the part number as symbolizing the product class and type, and accept the 4 as 4 in., the size of product, we can put B for bedplate. Thus—

Part No. RU4B.
Drawing No. RU4B.
Pattern No. RU4B.
First Operation RU4B/1.
Jig No. RU4B/1.

There may rise to the mind of the executive official the immediate rejoinder (and the very usual one): "Ah, but our works are different" or "We don't need these fancy systems." Well, we won't argue, for the writer admits that one can successfully reorganize within the boundaries of a hocus-pocus classification system. Classification will not organize a shop, nor will it show immediate visible savings, hence the general ignoring of its advantages.

THE ADVANTAGES OF LOGICAL CLASSIFICATION

Classification of a logical kind is essential for the placement of related parts in such an order that the relationship of one part to another is shown, that the significance of each part in the whole is brought out in a reasonable manner, and that identification of each part is made as easy as is possible. Classification is an essential to method in the sciences (page 2), as it should be in any field of knowledge where ordered activity is necessary. Logical classification in an engineering works of decent size making one or more complex products will—

1. Save time in writing job notes, parts lists, material requisitions, tool requisitions, and like mechanisms of shop operation.

2. It will make parts identification easier.

3. It will simplify filing and reference to filed information.

4. It will reduce errors.

PRODUCT CLASSIFICATION

The system of classification should, at least, cover the product, its parts, and the operations essential to its manufacture. The method of introducing a system of classification will be: (*a*) to list every product in hand and those likely to be repeated, and group classes; (*b*) to devise a single term for each distinct class of products (as "E" for engines, "P" for pumps, and so on); (*c*) to split the main class into types and adopt a term for each type, placing this with the class term (as "E" for engines, "ER" for reciprocating engines); (*d*) to divide the main class types into, say, sizes, and add a term to denote size; (*e*) to subdivide again down to parts and add a term to denote each part.

A good test for the executive to apply to any method proposed, and to each example of how it works out, will be to consider whether the system ensures the stores being able to identify parts easily and enables the youngest (and most forgetful) apprentice to get what he needs for his work.

In general, there is no one best method of naming class objects, but, as the main function of classification is to establish order, the method with the greatest appeal, to engineers at least, will be one which will not only identify parts in a written record, but will also assist identification in the shops. Thus, if by using a letter instead of a number the shops will be helped, it is as well to use a letter system as the basis. Numbers may be used for sizes of products and for operations. A system of this character can be denoted diagrammatically as in Fig. 5.

GENERAL STORES CLASSIFICATION

The classification of general stores, both direct and indirect, usually presents considerable difficulty to the executive official engaged on reorganization.

The approach is as with product classification; the alphabet is laid out and major classes booked, then these

are broken down into secondary classes, the alphabet being laid out for each break-down operation. The secondary class may similarly be broken down, and so on. It should be noted that one letter in the primary class used for product classification is booked for general stores.

As stated elsewhere (page 101), it is well for every engineering works to have a standard stock list. If such a list exists, it can easily be analysed into classes; if such a list does not exist, the act of getting it out can also be the act of classifying.

HOW MUCH CLASSIFICATION?

Classification may, and does, go much farther in some companies than is outlined above. Thus all expense accounts may be covered, as may all incomes, a letter in the main class (see Fig. 5) being allocated for the purpose.

It is not, however, suggested that to break down the classification to the operation stage is absolutely essential, although it is certainly profitable. A simple break-down covering (1) product class, (2) design type, and (3) size will be a great help in most companies where this break-down or a like one can be made. Numbers can, if desired, be used thereafter.

Such a simple break-down as this will ensure that, say, letter "G" will not mean one thing as first drawing letter, another thing as first part letter, and yet another as first pattern letter; it will always stand for, say, "Gear."

There is a fervid and to be expected opposition to full classification method in most engineering companies. Yet, if the writer's experience is of any value, when the job is done it will repay the trouble and patience required. If, moreover, all the products be allocated in the first series of letters, and one product at a time then be tackled, the job can comfortably and easily be done.

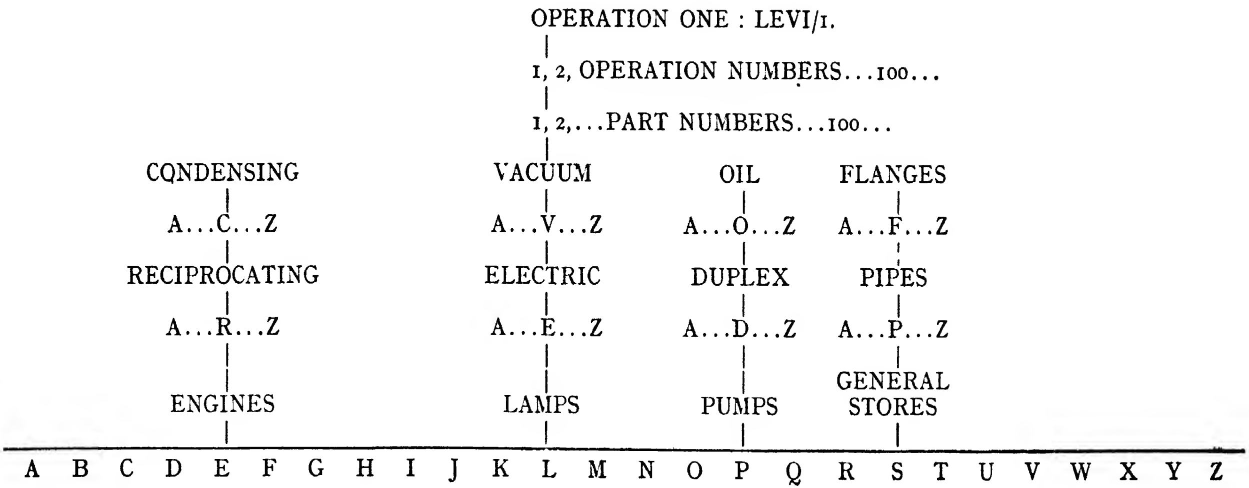


FIG. 5. BASIS OF CLASSIFICATION

PRINCIPLES OF LOGICAL DIVISION

It is at the breaking down, division stage that many systems of classification go wrong. The following principles of utilitarian division will act as a guide—

1. Utility must be the first consideration.

2. The one principle of the division must be stated and be kept to throughout.

For example, you decide to break-down on the basis of product design; if you change over to division on the basis of product weight or sales volume, trouble will arise. You may in the process of division arrive at weight, but the fundamental principle must be design.

3. No part of the division must include any other part.

4. The constituent parts of the division at each level of the division must equal the genus or whole.

5. The division must proceed from the genus or whole to the smallest species or part in a gradual manner.

These principles apply to product division and to problem analysis and are worth memorizing.

CHAPTER VI

HOW MUCH RESEARCH?

RESEARCH is conscious searching for and proving of knowledge. Scientific research is conscious searching for and proving of knowledge in a disciplined manner, the discipline being inherent in the method used. The method of science is Scientific Method, for a statement of which see Chapter I.

KINDS OF RESEARCH

Research can be classified in terms of its purpose as follows—

Pure research: disciplined search for and proving of knowledge for knowledge' sake.

Utilitarian research: disciplined search for and proving of knowledge for the use-value of the knowledge.

Each of these can further be classified, in terms of the field of application, as organic and inorganic, and, furthermore, the inorganic as physical and chemical, and the organic as physiological and psychological. What is usually called commercial research is really only one aspect of economic research, and this field of research comprises both inorganic and organic research covering, as in market research, both psychological and physical factors.

RESEARCH IN INDUSTRY

When one reads of research in industry it is unfortunately true that the obvious conclusion seems to be that what is called "technical research" is of greatest importance. The importance of physical research in industry is admitted, but methods research and humanistic research are also important.

Physical research alone is precise and scientific, and the

others, methods research and humanistic research, despite the use of the term "scientific management," do not lend themselves, when in conjunction, to the disciplines of scientific research method; unfortunately they always are in conjunction. Perhaps it is for these reasons we find research generally meaning "physical research." Elsewhere we touch on market research (Chapter XXVII) and humanistic research (Chapter XXI), but methods research is the major theme of this book.

ANALYSIS OF PHYSICAL RESEARCH EFFECTIVENESS

Nearly all engineering companies do physical research for a utilitarian purpose, a few do basic physical research (into composition, structure, and behaviour of materials), more do product research (behaviour of materials in a product or products), and nearly all do trouble research (why materials have behaved in the wrong way). It should, however, be noted that basic, product, and trouble research need not, because it is research, be scientific research. Indeed, the writer has been in contact with quite big "research departments" in which investigation was on the basis of this one or that one's notions, and the research moved in an undisciplined fashion to its useful or useless close.

At the risk of generalizing overmuch, we may consider the main criticisms regarding physical research in engineering as—

(*a*) Companies which have research departments use most of the research effort on "trouble research," usually because there was no product research in the first place.

(*b*) Similar companies to the above have not applied the disciplines of research method to their particular fields of research.

(*c*) Companies which should do product research do none at all of any kind.

(*d*) Small companies do not do as much as they might on organized library research.

(*e*) It is seldom in either the large or the small company that full advantage is taken of the researches of other companies, of research associations, and of individual research men, as such researches are made known.

SIMPLE BASIS OF RESEARCH

Here we are not concerned with the research organization on which, perhaps, £20,000 each year is spent; we are concerned with the simpler basis of research—even of trouble research.

One of the axioms of disciplined research is that the results of other people's researches must be known and codified if one's own research is not to be wasteful; the partial or full codification of others' researches is what every company can and should do.

But it is not sufficient merely to buy a few journals, research pamphlets, or books, and let these loosely circulate round the office. A library should be started, a proper subject index got out, and the people responsible for reading each class or type of literature and abstracting and codifying useful information listed.

The larger company, employing from 750 people upwards, will probably have a reader-librarian whose responsibility it will be to keep in touch with research association work and to abstract from current literature any data of use to the company. This data may have to do with methods, marketing, and humanistic matters as well as with physical research data.

RESEARCH METHOD

Whatever be the size of research organization, and whether the subject be trouble, product, or basic research, the right method should be used. Even in large organizations one may find this sort of attitude—

A: "What about that research into tool life?"

B: "Oh, yes, would you like me to start?"

A: "Yes, get a few tools and take brinells on them, then number them and get them into the shop and ask for a report on them. You know, the metal cutting feeds, speeds, depth of cut—you know."

B: "Right. I'll get down to it."

This kind of approach may get good results, but (*a*) not such good results as may be had with better method, and (*b*) it may get no decent results at all.

Every research should have a specific objective, it should be analysed to its elements, other people's experience should be checked on each element chosen, the importance of each element in terms of the objective should be graded, and only when base facts are clear should one proceed to dependent elements.

The above is a short and rough statement of the principles of methodical approach given in Chapter I.

EXAMPLE OF RIGHT APPROACH

Fig. 6 shows the general approach to the problem of hob wear. The technique here used is as follows—

1. Assistant chosen for analysis of data.

2. Instructed to break down problem to its elements.

3. Instructed to code each element in order of importance to the company.

4. Instructed to get out list of references to whole subject and to elements, giving author or authors of each reference, academic or other qualifications of these, and year of publication.

5. Combine whole in a report suggesting line of approach and effort and time required.

7. Decision made by Research Chief for work to proceed or otherwise.

More than one good research man at first resents the

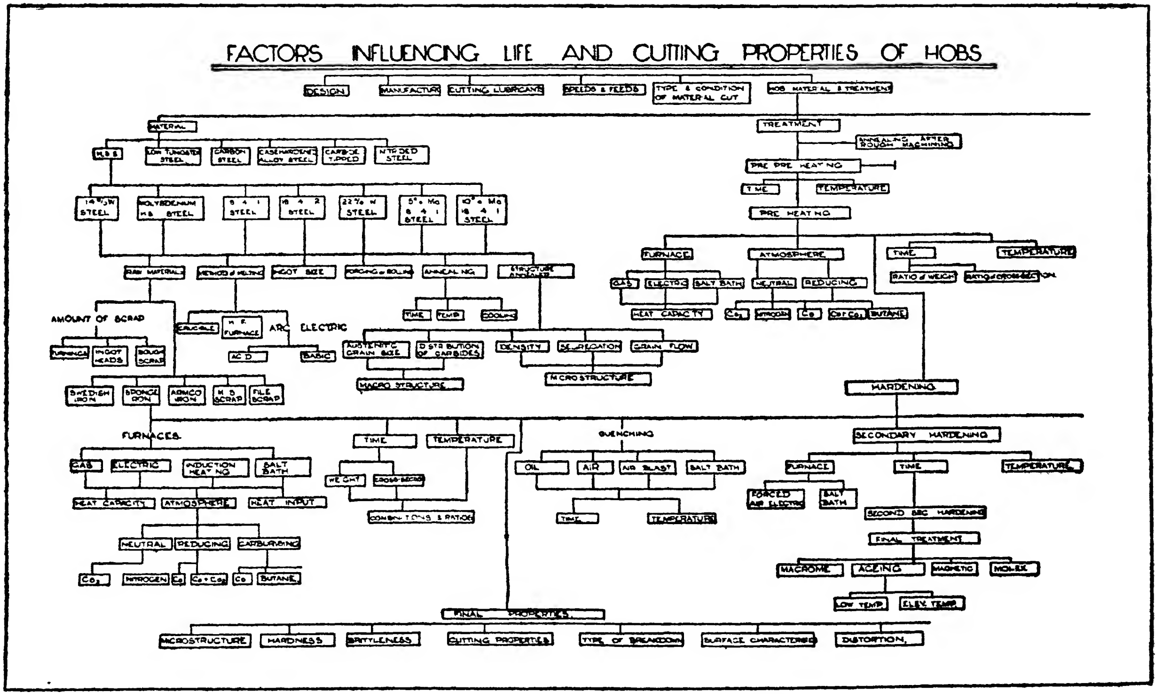


FIG. 6. EXAMPLE OF RESEARCH APPROACH

imposition of such a discipline as this, arguing (*a*) that it covers needless ground, and (*b*) "I know it all in any case," but the author knows many who, after trying it, realize that here is scientific method.

We have not room here to expand on instrumental and general method; the principles of these are given in the first chapter. It is not, however, in these that research men fail; as has been said, it is, from the author's experience, in (*a*) method of approach and (*b*) failure to use codified experience. No matter what size the company, neither of these need ever be wrong.

COST OF RESEARCH

The *Cost and Production Handbook*[1] gives American research expenditure as varying between 1 per cent in forty instances in each hundred to 10 per cent in eight instances in the same hundred. It is unfortunate that what is included in the foregoing percentages is not clearly stated, and for this reason the figures are of doubtful value.

Numerous engineering companies are, as stated, engaged on "trouble" research; but this, unavoidable as it may be in many cases, can hardly be classed as research in the strict meaning of the term; it is rather a design-drawing office activity.

The writer has come across only four engineering companies with definitely defined research organizations, and their running costs, including library, laboratory and staff, test-room and staff, designer, research men, and chief's salary, were between 1·2 and 2 per cent of net sales value. Note that what is often called development (drawing office work) is not included, nor are works and sales investigating procedures.

[1] Ronald Press, New York.

CHAPTER VII

THE DRAWING OFFICE

PLANNING really starts in the drawing office. From there comes the decision on what is to be done (product engineering), and it is important that any analysis of production organization and control start at this point.

ANALYSIS OF DRAWING OFFICE EFFECTIVENESS

We here have no intention of making any statements, comparative or otherwise, on drawing office costs. The writer has various ratios in his possession, but in fact they are of interest value only. For each company a cost ratio for drawing office to x will require to be worked out on the basis of experience and good management.

The following approach to analysis of drawing office practice may be helpful—

1. Consider drawing size standards.
2. Consider works' sketch sheets size standards.

(Both of the foregoing points are important from the standpoint of economical printing, storage of drawings, and buying of materials.)

3. Consider method of mounting drawings. If mounting is not practised, consider average number of print replacements because of wear and tear and loss, and cost this against mounting cost.
4. Consider standard for projection—is there a standard? Similarly for sectional views.
5. Consider if scales are rightly used. Is any drawing showing the use of a certain scale and then, on radii, say, showing out of this scale?
6. Are printing and titling plain and non-ornamental, and is there a general standard for this?

7. Are operation drawings used? If not, would their occasional use (as for a billet which is first forged, then turned, milled, key-seated, and ground) help the shops more than would part drawings of finished articles?

8. Is it practice to leave, say, plating shop and weld shop foremen to do their own developments? (This appears often to be the case.)

9. Is there a standards book, covering, for example, standard tolerances (see Chapter VIII)?

10. Are standard tolerances interpreted correctly by draughtsmen?

11. Is the system of dimensioning the "datum line" or the "chain" type, or mixed?

12. Is the method of showing dimensions standard? (Similarly with tolerances.)

13. Is there a rule covering position of dimensions on drawings?

14. Are drawings checked by an independent checker who signs as such?

15. Are shop prints distinct? Is the distinction between part outline and dimension and centre lines clear? Are sections cross-hatched to avoid mistaking for full views?

16. Are imaginary dimensions (e.g. pitch circle on a gear) given on drawings, thus confusing the turner? These should be shown in, say, a table on the drawing.

17. Are sub-assembly drawings used where necessary, or is there dependence on assembly drawings only?

18. Are assembly drawings merely outlines, or are they true pictures of the components and cross-referenced to parts lists or bills of material?

19. Are drawing numbers significant of what is drawn, and do they tie up with any other department numbers—or is the system purely a drawing one with no significant relation to part name or function, or to processes? (See Chapter V.)

20. If clients send in drawings, are these issued direct to shops? Where drawing standards vary from the company's, would re-drawing avoid mistakes?

21. Are proper parts lists issued? Are these designed for ease of finding drawings and for ease of material issue and sub-assembly and assembly parts collection and checking?

22. Is there a *central* system of record cards for designs which are likely to be used again and which refer to existing drawings?

23. Is there a cross-reference index from order numbers to drawing numbers?

24. Where similar units are made to one order, are these units clearly numbered so that alterations to the parts of any unit can be traced if replacements are needed?

25. Is there a strict method in operation to ensure that all alterations in the works which differ from drawing standards have drawing office sanction and are duly recorded by the drawing office. If so, are records effectively kept?

26. Check up on drawing office filing system for speed and accuracy by test. Is filing equipment good?

27. Check up on method of altering drawings once these have reached the shops.

28. Is there a drawing alteration note, one copy of which is kept in the drawing office, one sent to planning, and one kept by the department in which drawing was altered?

29. Check up drawing office stores control method. Is there a requisitioning or (in the small shop) a book-signing system for more valuable materials?

30. Is drawing equipment up to date?

31. Are lighting, heating, and ventilating conditions conducive to best work? Is there freedom from noise?

32. Does each section leader book all work done by each member of his section? On what basis are times codified? Is this the basis of estimating drawing costs and times in job estimates?

33. Is there a load record, by sections, of work in hand? Is the flow outwards of drawings scheduled in terms of works planning?

34. Is there a defined tie-up between drawing office, processing, and jig and tool design?

35. What is the method of training draughtsmen? Is the method the somewhat usual and selfish one of getting a good lad and keeping him in the office without shop experience?

36. Is there scope for young people in the works to get to the drawing office and, from there, to process and production planning and to management? Is this defined, and on what basis is move made? (Drawing offices up and down the country are cluttered up with men who could, given opportunity, have made excellent production men and administrators. Often one finds shop foremen paid 25 per cent more than draughtsmen—why not recruit and train foremen from the drawing office?)

We cannot hope to cover all of the foregoing points in this chapter—hence the method of critical lay-out, drawn up to enable the engineering manager and the drawing office chief himself to approach the problem methodically.

A word in season. The drawing office is the one place where concealed planning of new techniques does not pay. If the draughtsmen's interest be integrated with the purpose in mind, it is likely that a lot of help from them will be forthcoming.

THE PARTS LIST

This is variously called the "bill of material" and the "material card" in different shops.

In some quarters there is a tendency to make the parts list do too much. Thus Diemer,[1] in common with other writers, suggests it should bear not only material name,

[1] *Factory Organization and Administration* (McGraw-Hill).

type, quantity, and the like, but also time-study number and tool-list number. As the bill of material has to do with parts and not operations, the putting in of the time-study and tool-list numbers seems rather ineffective, and, after all, why should not the drawing number, the pattern number, and the part number be the same, with, for operations and the jigs and tools required for these, the addition of "stroke-operation" number? (See Chapter V.)

PARTS LIST

Order No.: No. of sheets:

Sheet No.:

Description:

List-sheet No.: Arrgs. Drg. Delivery:

Client's parts:

Nameplate:

Item No.	Description	No. Off	Matl.	Quan.	Issues	Drg.	Patt.

FIG. 7. PARTS LIST

The parts list shown (Fig. 7) is typical of one used in engineering works known to the writer and employing from 100 to 2000 people. On the list given, room for pattern and drawing numbers is shown, but, as stated above, the idea in most shops of using different sets of numbers for drawings, patterns, and parts requires revising.

It will be noted that the parts list requires that the drawing office decide on quantity of material to be used; it will be necessary that the standards book give parting-off and gripping allowances for various classes of machines; plating, press, and forge shop allowances will be calculated—

the last in conjunction with data on die and hammer practice from the shop.

Except in very small works, the use of the parts list as a cost record is not to be recommended. Its use, however, as a customer's order history card (Fig. 8) is to be recommended in most works where, even if part route cards (Fig. 50, page 184) are used, there is no complete history of parts released and finished. Where the parts list is used for costs, it is usual to add four columns for material, labour, overhead, and manufacturing cost respectively; but if costing is departmental or on a machine or labour-hour basis of overhead recovery (see Chapter XXIII), more columns are used.

Parts lists may be written in pencil, then typed or duplicated; but for most purposes the parts list reproduced from tracing linen is best. Where possible, sub-assembled parts should be listed together *and the sub-assembly number given*; whether they are listed together or not, this sub-assembly number should be given.

On purely special work, the parts list may be used as the authority for issue of material to the fitting shop, a fitting shop copy being brought to the stores and signed by the storekeeper on issue of material, the receiver signing the stores copy. On mixed production, however, a material card copied from the parts list is used (see Chapter XII).

COMPLETE LISTS NECESSARY

In works in which the writer has operated there is usually found a shortage of part and material listings. The following are typical—

Bolts and nuts from general stores.
Washers and split-pins.
Grease nipples.
Gaskets and bearing packing material.
Paper, sticks, and tape for stators and armatures.
Testing grease and oil.
Nameplates.

PARTS LIST

Order No.:
Description:

No. of Sheets:
Sheet No.:
Delivery:

Final Test-sheet No.:
Sectional Arrangements:
Client's parts and gauges:
Nameplate Detail:

Item No.	Description	No. Off	Material	Quan.	Issues	Date Finish	Op'n Dates						
							1	2	3	4	5	6	7

FIG. 8. COMBINED PARTS LIST AND MASTER HISTORY CARD

The results of these and more serious omissions on material control is grave. Thus an attempt should be made to cover all items, down to the quantity and types of filling and paint to be used.

One or two works go as far as designing the case for the packing of special machines. This, in certain instances, is a wise and economical precaution. It is obvious, of course, that for stock products the cases or skids should be standard design and stated on parts list.

THE DRAWING

There is still a fair percentage of engineering works where sub-assembly drawings only are used for the guidance of the production departments. The chief executive officials of the works where this practice holds usually argue that part drawings are not necessary, as both machine and bench hands know the products. Usually no tolerances are shown on these drawings.

About the foregoing the writer can only say that: if fitting and test costs are not anything from 50 to 90 per cent too high (actual figures from experience), then, indeed, either the product is a very simple and repetitive one or the works people are a grand bunch of engineers.

PART DRAWINGS

Yet another practice is to show numerous parts on a single drawing instead of using drawings for each part. This method is thirty years old, and the arguments for it (paper-saving is the chief) do not balance the arguments against it: borrowing of and waiting for drawings by operators, difficulty of effectively making part alterations, bad drawing, definition, numbering, and filing are a few. Moreover, part drawings allow for better labour utilization in the drawing office itself.

The use of part drawings is modern practice, but in many

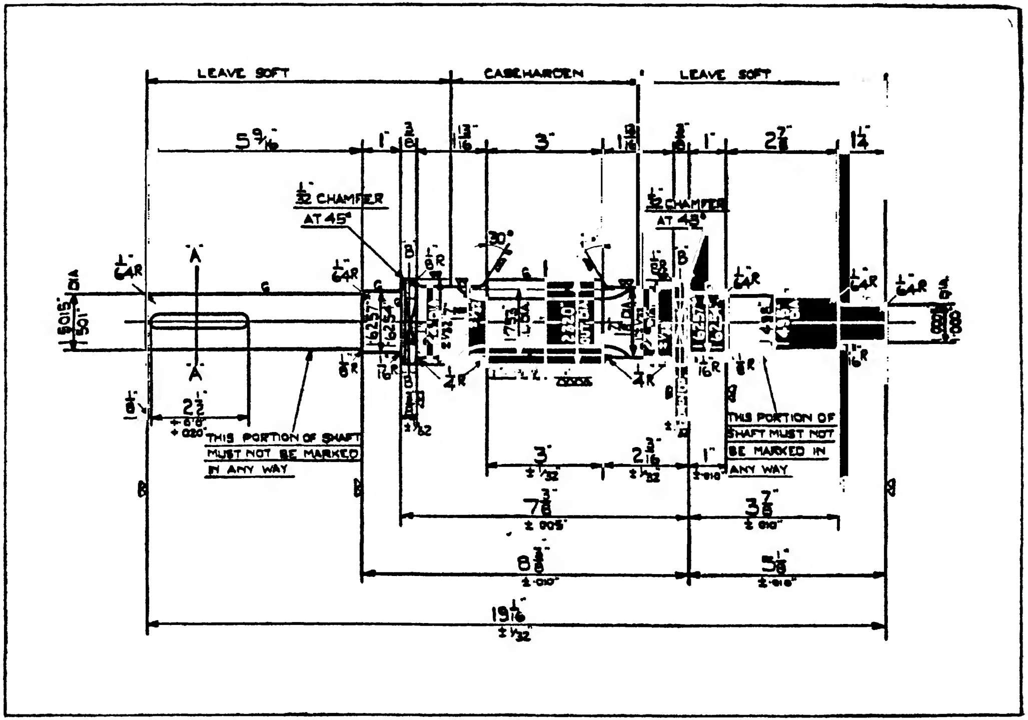


FIG 9 EXAMPLE OF POOR DRAWING TECHNIQUE

shops the use of operation drawings would be a help. A case in point is where an attempt is made on one drawing to show by a chaotic representation of plan, front, side, and sectional views a billet with its dimensions, the forged billet with its dimensions, the turned forging with its dimensions, the ground forging with its dimensions, and milling, screwing, casehardening, drilling, and other detail—all on one set of views.

Where the operation drawing is used, the operation lay-out and method can effectively be shown on it—an obvious advantage on batch and continuous work.

Fig. 9 shows a drawing typical of those used in many engineering works, and Fig. 10 shows the same part drawn in a more readable fashion; the difference between the use of chain dimensioning and dimensioning from a datum line are well illustrated, as are differences in figure placement, statement of tolerances, and part and dimension line thicknesses.

STANDARD METHOD

An essential of drawing office practice is standardized projection. Whether the method be that placing each view so that it represents the side of the object remote from it in the adjacent view (first angle) or the side of the object near to it, the method should be general in the works. The method of showing sectional and auxiliary views should also be standard.

Scales should be standard, and the scale used on a drawing should be the scale used throughout the drawing if at all possible. For production drawings, standard scales are full, half, quarter, and eighth full size, and, for lay-outs, the foregoing plus $\frac{1}{2}$ in., $\frac{3}{4}$ in., 1 in., $1\frac{1}{2}$ in., and 3 in. to the foot.

This is not a treatise on drawing practice, and we are interested in drawing largely from the production standpoint. From that standpoint, however, it is worth repeating here some of the accepted rules of drawing office good practice—

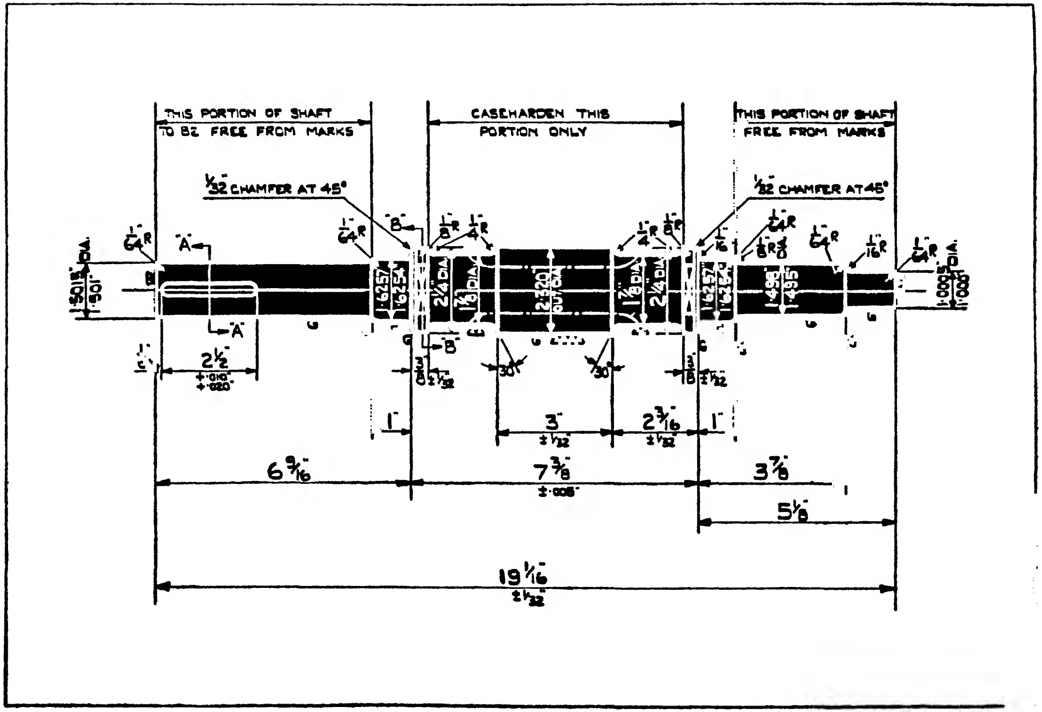


Fig. 10. Example of Normal Drawing Technique

Dimensions should be placed on (*a*) horizontal and inclined lines to read from left to right, (*b*) vertical lines to read from bottom to top. Dimensions should generally be given from or about centre lines; they should be outside the view if possible, and should generally be placed between views.

FILING OF DRAWINGS

The argument on the merits of filing of drawings vertically and horizontally, respectively, is not new to drawing offices. The first cost of vertical filing seems to be the lower, but operating costs, so far as rough analysis has shown, are about the same for both methods.

From the standpoint of space-saving in filing and low cost of protection against flood, fire, and bombs, the photographic method is especially worthy of notice. The method claims to, and indeed does, reduce filing space to a quite remarkable degree.

The release and return of drawings from and to files should be closely recorded. In fact, it is usually profitable to have someone in sole charge of the files, or, in the smaller offices, of files and stores. Blueprints issued to works should also be recorded; in some instances a card is kept for each tracing, and a record of blueprints issued from the tracing is noted on the card—this will in many ways be found to be a useful record.

Filing is generally done by machine or product class or by consecutive numbers; again, one finds the filing of drawings by the size of drawing sheet. It is difficult to give a concise general ruling on the best method, as each has advantages and disadvantages. Where the same drawing may be used on more than one machine and sizes of drawings vary greatly, the use of a record card (the blueprint issue card mentioned in the previous paragraph will serve) in conjunction with filing by drawing dimension will be

found economical in most instances; the cards would be in machine order.

DRAWING OFFICE RECORDS

Apart from the records mentioned above, there should be a record of allowable dimensional variations in standard parts. These may be kept on cards, one for each variation, or, the writer prefers, on standard data sheets in the standards book (see Chapter VIII). Note that a copy standard sheet may be used for a drawing, with type to be made clearly indicated thereon.

Perhaps one of the most valuable records in the drawing office, and the one most neglected, is that used to note details of any part allowed, for any reason, to pass inspection into a product when the part is outside the dimensional standards stated on the drawings. In many businesses the shops are fairly well allowed to use their discretion about informing the drawing office of departures from drawing standards, but in any works it should be a rule that *no part which is outside the dimensional standards shown on the part drawing should be allowed to go into any product without full information thereon going to the drawing office prior to assembly of the parts.*

It is little wonder that in many cases the draughtsmen get "fed up" with the works, when in fact the works override drawing office technical skill and knowledge by altering, without as much as if you please, the recorded decision of the drawing office staff.

A useful record of the drawings on any particular product, and one which gives a cross-reference from order number to drawing numbers, is the product drawing list or, if desired, a filed copy of the parts list. This latter, though it carries items not drawn, serves the purpose quite well. A design record card is shown in Fig. 11: this is almost an essential.

SPUR GEAR

No. of Teeth	Outside Diam.	Face Width	Matl.	Boss			Drawing No.
				Dia.	Bore	Lgth.	

FIG. 11. DESIGN RECORD CARD

ALTERATIONS, ADDITIONS, AND MISTAKES

Additions to parts lists are almost unavoidable in works making special products as distinct from purely stock products; so with alterations. Minor additions and alterations should be allowed for by leaving a blank line on each sheet of the parts list, and the parts list (all copies) should be withdrawn by requisition from the shops to the drawing office for the purpose in view. The more usual method of sending notes to the works covering additions and alterations should be avoided.

Alterations of dimensions in any way whatsoever on drawings should in most instances require the issue of new drawings. If works operations are done wrongly because of drawing office mistakes or wrong instruction, the cost of the works operations in question should be debited to the drawing office through the medium of an inspector's report and scrap or alteration notes.

TOLERANCES

Although one yet finds works using their own special tolerances when one of the standard series would serve

better, and although, too, the charting of these special tolerances often shows considerable "interferences" where none is intended, this is not a common fault. The common fault is wrong selection of tolerances from standard series.

The best practice in tolerance use for various classes of fits should be shown in a standards book (see Chapter VIII).

The draughtsman, however, should watch the common fault in the works of so operating jobs that the application of tolerances seems, at the assembly stage, to be quite wrong. A case in point is boring for ball bearings—often the bores are taken from the machine as good, then, at assembly, are too tight because the job has been finished while hot and has contracted while cooling. Surface-ground jobs to fine tolerances present the same problem. Unwitting demands from the works for tolerance changes because of these and other like practices are not uncommon; but, before changes are made, the drawing office should have the right to make a process investigation.

DRAWING OFFICE LOAD SHEETS

In few engineering shops has planning a chance of being effective if the total load and the sectional loads on the drawing office are not known at any period. Unfortunately this aspect of loading, though often mentioned, is seldom described, and what the writer here offers is far from perfect.

The head draughtsman, in conjunction with one or more of his section leaders as required, should estimate the total load on the drawing office as a whole and on the section concerned immediately any order is accepted and passed for design or for drawing. This requires that a bar chart on a time scale be used for each section and for the whole department.

On specials a rough list of drawings (Fig. 12) should be made from the design sheet, and, in terms of the load on the section concerned, a progress schedule should be made

DRAWING ISSUE SCHEDULE ESTIMATE FORM

Division :

Order No. : No. Off : Date Due : Designer :

Description :

Estimate No. : Present Load on D.O. : (in days or weeks) Present Load on Section :

Part Name	No. of Drg.	Estimated Time to Draw	If B/O	Time to Obtain (Days)	Shop Estimate Production Time (Actual)	Jigs, Tools, etc. Required	Estimated Time to Draw	Time to Make	Drg. Issue Date	Remarks

FIG. 12. DRAWING ISSUE SCHEDULE ESTIMATE FORM

out. This should go to the planning department for scrutiny as the basis for works scheduling. Any potential hold-ups owing to doubts about customers' exact needs should be stated on this list. Stock repeat orders, of course, require no new drawings.

Planning staff will probably alter the issue sequence in terms of part-operating times, the basic idea being that the longer the operating time the sooner the part must be in the shops.

If parts have to be bought out, the buyer should be called upon to estimate delivery, so that planning may be proceeded with.

Difficulties surrounding drawing office procedure in many engineering shops make laughable the claims made by various experts on planning. We shall return to the subject later (Chapter XX); meantime, we may put it thus: load charts and drawing issue sequence statements in the drawing office will seldom be more than 60–70 per cent accurate; but they are better than nothing at all, and without them production planning in the average engineering works will be a farce.

FALLACIES OF THE DRAWING OFFICE SPEED-UP COMPLEX

The author favours the booking of drawing times, but he does not favour pseudo-scientific organization of the drawing office on a time and cost basis. Perhaps here, more than elsewhere, does the application of "scientific" management totter to an early full stop.

Drawing is a 50 per cent manual cycle and a 50 per cent mental cycle, and the personal factor will not be eliminated. Drawing, further, is dependent to a large extent on team thinking, and who shall measure that, especially when we consider that the final cost of the product when drawn by the draughtsman who thinks a lot and takes advice may

be very much less than when drawn by the draughtsman who thinks a little and takes no advice, and turns out a quicker job?

The quick-job angle and the thorough-job angle clash in many drawing offices. Time budgets and bonus allowances foster low drawing costs and high production costs, and are, in any case, poor apologies for right management.

DRAWING OFFICE MANAGEMENT

It is seldom that the practice of having one chief draughtsman in direct charge of ten to twenty draughtsmen really pays. Drawing, to be effective, is generally the work of more than one person, and close contact with each draughtsman by the management brings best results.

Thus it is suggested that each five people engaged on production drawing work have a working section leader—a designer for preference. With this scheme a drawing office having twenty-five draughtsmen would have five section leaders, and, perhaps, a tracing section leader. Even where special stress and tolerance draughtsmen are employed, some such leadership of production draughtsmen is required in most engineering businesses.

In conclusion, and despite widely accepted theory, it will generally be found profitable to have process engineers alongside, if not under the same management as, the draughtsmen. The draughtsman determines "what shall be done to the job" and the process man "how it shall be done"; where both functions are close spatially and mentally, the most effective type of design will result—that showing the lowest ultimate cost commensurate with right quality standards.

CHAPTER VIII

THE STANDARDS BOOK

THE standards book is, in some form or other, an essential in every engineering company. Unfortunately, if tolerances are not considered, the majority of engineering concerns have no such handy mechanism as is represented in a standards book. For this reason it is unnecessary for us to analyse standards application effectiveness.

DEFINITIONS

A standard, in the first place, is an expression of attitude about what should or should not be.

The standard by which an operating group judges its foreman and the standard by which a chief inspector judges a product are both expressions of attitude, the first being, perhaps, largely emotional, and the second, let us hope, intellectual. However, we are concerned with judgments expressed in writing and having directly to do with engineering technology, and now that we have avoided the fault of defining a standard as if it were something quite new and confined to management activities, we may pin our definition down.

Standards in industry are objectified expressions of attitude on the most suitable means of carrying out industrial procedure, and may be applied to the procuring, retaining, and using of labour, material, equipment, and finance.

It will be obvious that a standard will be as effective as the quality of thought behind it is effective, and also it will be obvious that a standard may be unreasonable or reasonable in terms of the field of its application. Thus, to have a high-quality attitude and to attempt to express it through low-quality machines is unreasonable. If, then, standards

are to be set up, they should be the result of careful investigation, and they should be so expressed that they can be reasonably met with the reasonable means to hand.

BRITISH STANDARDS INSTITUTION PROGRAMME

It is a good rule of methodical investigation that the experiences of other investigators be first considered before any actual problem-solving be attempted. In Britain the British Standards Institution has produced over 800 standard specifications, together with close on 200 specifications for aircraft materials, and in America the National Bureau of Standards and the American Society for Testing Materials have done similar work on a more intensified scale.

Perhaps the best method when tackling standards institution is to get out a definite programme covering the various aspects of the business. Given it is agreed after investigation to begin a standards programme, the logical thing to do is to consider the kind of organization necessary to install the standards. A separate department is best, for if, as is usual, the work is carried out in conjunction with drawing office work, it will probably be poorly done. (See under "Costs," page 62.)

The following is the order, in terms of necessity, generally adopted for investigation and use of standards—

1. Limits and fits.

2. Standard equipment in works: drills, taps, gauges, broaches, mandrels, and the like.

3. Standard product parts: couplings, bedplates, keys, dowel pins, and the like.

4. Buying standards: specifications to cover buying of iron castings, steel castings, forgings, stampings, bar and sheet, bronze and aluminium parts, and the like. Tests for these. Buying procedure.

5. Standard stock.

6. Standard inspection procedure. Design of flow of forms (see page 85).

7. Drawing and parts list standards. Design and flow of paper (see page 48).

8. Material requisitioning, receiving, storing, and issuing procedure. Replacement procedure (see Chapter XII). Flow of forms.

9. Procedure for booking work and job times. Design and flow of job notes.

10. Tool standards (see Chapter XVI).

11. Tool requisitioning, receiving, storing, and issuing procedure. Replacement procedure (see Chapter XVI). Design and flow of forms.

12. Maintenance standards (see Chapter XV).

13. Transport standards (see Chapter XIV).

14. Machine-tool standards.

15. Standard machine-capacity sheets.

16. Office standards: desks, machines, pencils, papers, carbons, inks, rubbers, and the like.

The foregoing is not strictly a logical conception of standards institution; it is an actual routine dictated quite recently by necessity.

SPECIFICATION EFFECTIVENESS

Tolerances, other than those quite special, will be selected from published specifications; these, with lists of standard gauges, standard taps, drills, and broaches, will be blueprinted and mounted in book form. So with standard ranges of product accessories such as ranges of couplings, bedplates, keys, and the like. All of these should be published even in quite small works.

The approach to the use of materials specifications is, in small and moderate-size companies, often rather hesitant for some reason or other. Yet that specifications should be used is unquestionable.

A form for analysis of specifications use is shown in Fig. 13. The technique is—

1. Get out analysis sheet.
2. List all direct materials, showing grades of each.
3. List all indirect materials (oil, paint, etc.).
4. Fill in quantity used per year of each material.
5. Look up standard specifications to see if material is covered. If so, note specification.
6. Decide on extent of each test to be used, and note equipment required.

Chapter XIII covers the equipment of a laboratory to cover most engineering material specifications.

All specifications should be put in the specification section of the standards book, or a special booklet should be blue-printed.

PROCEDURE STANDARDS

Throughout the book we deal with various physical and procedure standards, but the subject is worthy of special note here because of the poor effects in many works owing to lack of standards for quite ordinary procedures; indeed, many excellent schemes of organization and control fall into gradual decay because the new scheme procedures have not definitely been made standard.

Procedure standards may range from standards of operator employment and dismissal to standards for disposing of swarf. The most essential, however, seem to be—

1 Standard inspection procedure as to work inspection, gauge and jig inspection, and passing and rejecting articles.
2. Material control procedure.
3. Time and work booking and day rate and bonus earnings procedures.
4. Tool-control procedure.

Most companies could, with profit, cover these in published form. Large companies will extend to transport,

SPECIFICATIONS USE ANALYS'S

DESCRIPTION	USED YEARLY	BRITISH STANDARD SPECIFICATION			EXTENT OF PRESENT TEST TAKEN	PERIODICITY	TAKEN BY WHOM	IF WE SHOULD USE B.S.S. TEST	EXTENT OF TEST	IF WE HAVE MECH. EQUIP^T	IF WE HAVE CHEM. EQUIP^T	EQUIPMENT REQUIRED	EXTENT OF TEST FOR -					ANALYSIS
		NO	DESCRIPTION	IF TESTS TAKEN HERE									BARS	BILLETS	FORG.NOS	STAMPINGS	CASTINGS	
FREE CUTTING STEEL	54 TONS	GRADE 1 32/1935	C MAN SI S P CH MECH PHYS	NONE	NONE	NONE	–	YES		YES	NO		1 TENSILE 2 IMPACT/M					2/MONTH
BRIGHT DRAWN STEEL	127 TONS	5006/105	C.S. MN S P CH MECH PHYS BEND	NONE	NONE	NONE	–	·										
IRON CASTINGS GRADES A B C	2,250 TONS	32/1928	CHEM PHYSICAL		NONE		–											1/CAST
ALUMINIUM CASTINGS	30 TONS	3L5	ZINC COPPER AL^M CHEM PHYS		NONE			·										
FORGINGS	40 TONS	VARIOUS	SEE STD SPECIFICATIONS		BRINELL		INSPECTOR	YES	ALL	YES	NO	–		HOT ETCH				

FIG. 13. SPECIFICATIONS USE ANALYSIS SHEET

maintenance, planning, ratefixing (for standard constants, see Chapter XVIII), purchasing, and employment procedure publication. The field covered will be limited only by management outlook limitations and, of course, by type of products and size of company considerations.

EXAMPLES OF SAVINGS

Standard procedures publication saves duplication of effort and avoids results of erratic practice. These savings are somewhat immeasurable, but are none the less important. Perhaps it is in the getting out and standardization of stock and equipment lists that greatest savings arise. The following are actuals from engineering works—

Kinds of paints reduced from 23 to 9.
Kinds of cord reduced from 12 to 5.
Kinds of envelopes reduced from 28 to 12.
Kinds of bedplates reduced from x to 18.
Kinds of bolts reduced from 96 to 49.
Kinds of pencils reduced from 15 to 9.
Sizes of drills reduced from 186 to 88 (64ths cut down—flat-top threads used).

The foregoing are published to illustrate the wide field of application of standards—a small test on the seven items mentioned in any company will perhaps give a lead to the management.

COST OF STANDARDS DEPARTMENT

It is exceedingly difficult to give ratios with a wide significance to cover the cost of standards, owing to the very small percentage of companies with a separate standards department. Even with only one man in the department the cost of this man, if the job is to be done effectively, will be higher than that for, say, a designer or a planner.

From experience, the writer suggests that the average general engineering company employing 500–600 people can profitably afford the services of a standards engineer. The company employing about 200 people can profitably

combine the tasks of tolerance draughtsman and standards engineer. An assistant and a tracer (who can type) will be necessary.

But the state of the company on quality and bought material standards and on elementary procedures, the kinds of products made, and the number of products made are factors which will limit the significance of the suggestions given above—they are indicative only.

CHAPTER IX

MECHANICS OF QUALITY CONTROL

IT has already been remarked, in effect, that the maximum tolerances[1] allowable on product parts should be put on drawings, and that these should not be the result of the opinion of a draughtsman but should be based on economical standard practice—expressed, if possible, by a "limit draughtsman."

While it is true that lack of tolerances and wrong tolerances are not unusual in engineering works, it is in the attempt to fulfil the standards set by the drawing office that most companies fall short.

ANALYSIS OF QUALITY CONTROL EFFECTIVENESS

When one considers that one company may spend thousands of pounds on measuring devices and the conditions for their use, and another company be quite effective though spending only a few hundreds, it will be apparent that there is no universal yardstick by which one can reasonably measure the effectiveness of quality control in all engineering companies. But the quality control should be as strict in the small as in the large company, because, whatever the size of company, for the particular product or products made, standards must be maintained.

One could start off the investigation by taking sample parts, checking which of the dimensions are standard (running, forced, pushed, and press fits and the like), then querying if standard gauges are used at production and at inspection. This study in many companies will be quite illuminating, for it may be found that the correct type of

[1] Tolerance is a difference in dimensions to allow for, or tolerate, imperfections in workmanship.

gauge is often not used where it should be used. Companies whose employees are allowed to discriminate as to the type of gauges to be used will probably find both operators and inspectors smitten with "micrometer fever" and, thus has the writer found it, on screw threads, either with "good bolt or nut" or the "no gauge at all fever."

The next step may be the analysis of gauge-checking. How, and how often, are gauges checked? What are the tolerances allowed on gauges? What is the accuracy of the device used for checking gauges?

A similar technique may then be adopted with jigs and fixtures.

The investigator must not be surprised if he gets a rude shock when the result of his investigations comes out. The idea of quality control is only slowly being formulated, and few companies are as yet "gauge-conscious" in the basic sense. It is not untypical that in two companies recently contacted by the writer, of gauges in use 45 per cent and 68 per cent respectively were wrong in dimension, and, of jigs, 67 per cent and 62 per cent respectively were either scrap or in need of correction.

THE SIMPLE BASIS OF GAUGE CONTROL

If we take, as an example, a plug gauge with a tolerance of 0·001 in. between the "go" and "not go" ends, and consider the checking of this gauge, we shall, by a series of backward steps in reasoning, arrive at a fair idea of engineering works basic measurement. We can reason thus—

1. The gauge must be checked.

2. The device for checking it should be more accurate than the gauge.

3. How much more accurate than the gauge must this checking device be?

4. And how accurate should the gauge be? In other words, when is the gauge scrapped?

We may, in the absence of published standard data, accept that the device for measuring gauges be ten times more accurate than the gauge itself; that is, in the case of our gauge, we require a device accurate to $0{\cdot}001/10 = 0{\cdot}0001$ in. (one-tenth of a thousandth of an inch). Let us say we use a micrometer (which Heaven forbid); then how are we to know the micrometer will read accurately to 0·0001 in.? It seems we shall need a measuring standard accurate to $0{\cdot}0001/10 = 0{\cdot}00001$ in. (ten-millionths of an inch), and that, in effect, is what most engineering companies need. In, however, the engineering company working to tolerances of 0·0002 in., the need is, it seems, for a measuring standard accurate to 0·000002 in. (two-millionths of an inch).

NECESSARY EQUIPMENT

Just as every country has a standard of measurement, so is it necessary for every engineering company to have its own standard of length. Several reliable companies have produced reference blocks or slips.[1] One such set of standard slips is shown in Fig. 14; standard-length bars are shown in Fig. 15. The slip gauges can be "wrung" together to build up various lengths, and when it is considered that the reference or standard slips are to within $2\frac{1}{2}$ parts in a million, and the workshop slips to within 5 parts in a million, the value of these gauges will be realized.

Every engineering shop should have at least one set of slip gauges and (usually) one set of length bars. To take general engineering as a case in point, the following may act as a guide from practice—

[1] Johansson, Pitter Gauge & Precision Tool Co., Pratt and Whitney Ltd., and Zeiss make and supply standard-length blocks and bars.

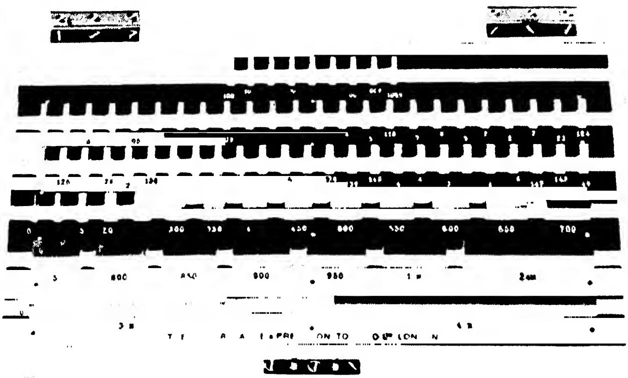


FIG. 14. STANDARD SIEVE GAUGES

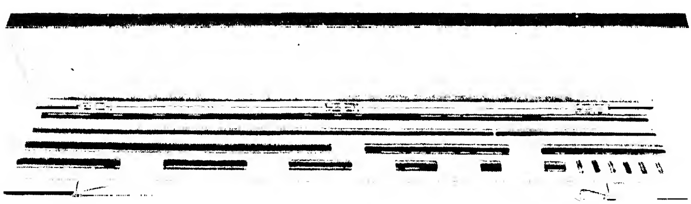


FIG. 15. STANDARD LENGTH GAUGES

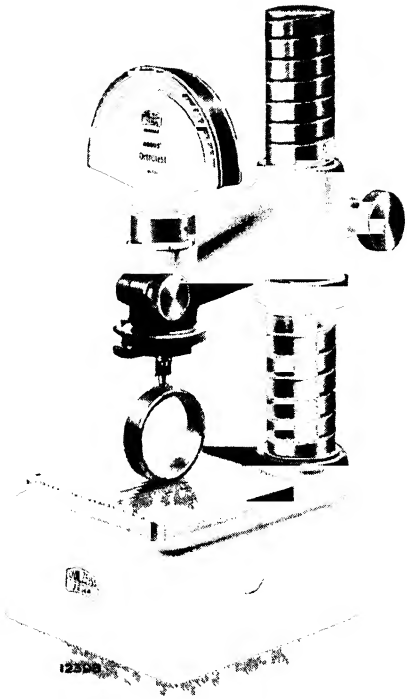


FIG. 16.—0·0001 IN. COMPARATOR

Courtesy of Messrs. Alfred Herbert Ltd.

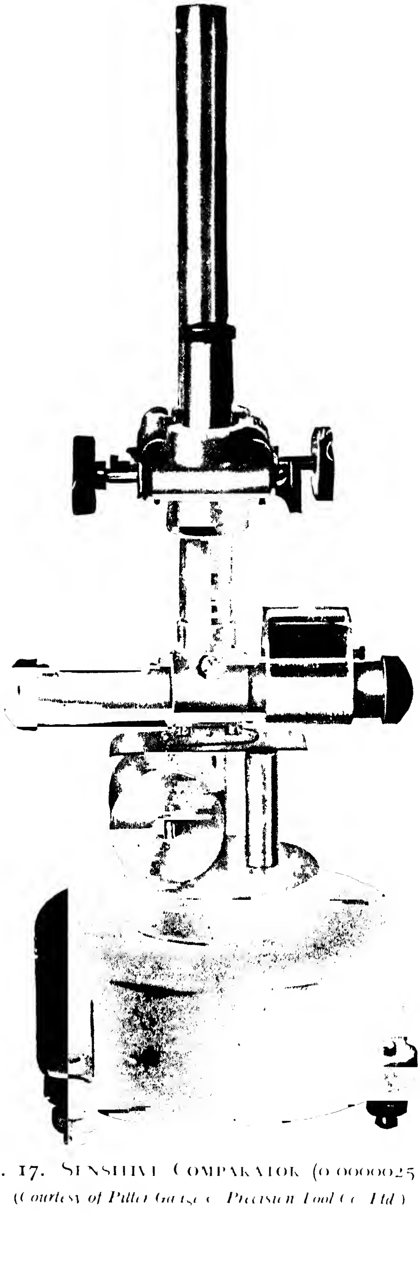


FIG. 17. SENSITIVE COMPARATOR (0.0000025 IN.)
(*Courtesy of Pitter Gauge & Precision Tool Co. Ltd.*)

Number of Employees	Sets of Gauges	Sets of Reference Length Bars
70	1 std. 1 workshop	1
200	1 std. 2 workshops	1
500	1 std. 4 workshops	2
1000	1 std. 10 workshops	2

But while slip gauges may be used to set, say, adjustable calliper gauges and to test micrometers, it will be necessary to transfer their accuracy to a measuring device if plug gauges are to be measured. For this purpose a comparator indicating to an accuracy of about 0·00005 in. is used. One of these is illustrated in Fig. 16.

For the small engineering shop on general engineering work it is recommended that one of these comparators, one set of slip gauges of the reference or standard type, and one set of the workshop type are necessary, the former set to be used only by inspection. On large work a set of standard-length bars may be necessary.

With the above equipment it will be necessary to have the reference gauges checked (by the National Physical Laboratory or by the makers) at definite periods.

The large shop (employing, say, about 1000 workers) will check its own standards of length. One set of standard gauges will be used only for this purpose, with a sensitive comparator (see Fig. 17), reading accurately, in inches, to the order of 2–3 parts in a million. A temperature control room, where slip gauges are checked, will be necessary. Even in the small shop, as slip gauges are calibrated at 62° F., gauge growth owing to temperature rise will have to be avoided.

The foregoing equipment will cover the testing of calliper gauges and the setting of adjustable calliper gauges, testing of micrometers, testing of plug gauges, and, in general, the checking of length gauges. In the case of the company

having a sensitive comparator, the checking of slip gauges will also be covered. Taper gauges may be tested in a type of sine bar fixture,[1] or with slip gauges and calibrated rollers.

The small engineering shop on general production may use a screw-thread micrometer for checking the outside, core, and effective diameters of male screw gauges. If screw threads produced are for aircraft, automobile, steam or oil engine, machine-tool, and, in general, for products subject to vibration and intense stresses, it may be found necessary to invest in an instrument for measuring the thread angles, as well as pitch, outside core, and effective diameters. A ready help will be found in an optimeter or in a tool-maker's microscope (Fig. 18), but if female as well as male screw gauges are to be checked, a universal microscope (Fig. 19) may be required.

GAUGE MANUFACTURING AND WEAR TOLERANCES

It is a peculiar fact that while numerous engineering shops have gauge measurement, very few indeed have definite ideas on gauge and gauge wear tolerances. Indeed, the writer could quote a dozen examples of companies making their own gauges without any very clear ideas on gauge tolerances.

It will be obvious that when a solid gauge is made the tool-maker will require that a tolerance be given him, for obviously he cannot work to exactly defined sizes. It is also obvious that the allowance given to the tool-maker must be deducted from the gross tolerance allowed on the drawing. If one-tenth of the gauge tolerance is allowed the tool-room, and we take the "go" end of a plug gauge whose bottom limit is 1 in. with a tolerance of 0·001 in. on the work-piece, the tolerance to the tool-room would be 0·0001 in. But the tool-room may produce the gauge to size 1·000 in., and at the

[1] Supplied by most of the manufacturers mentioned on page 66.

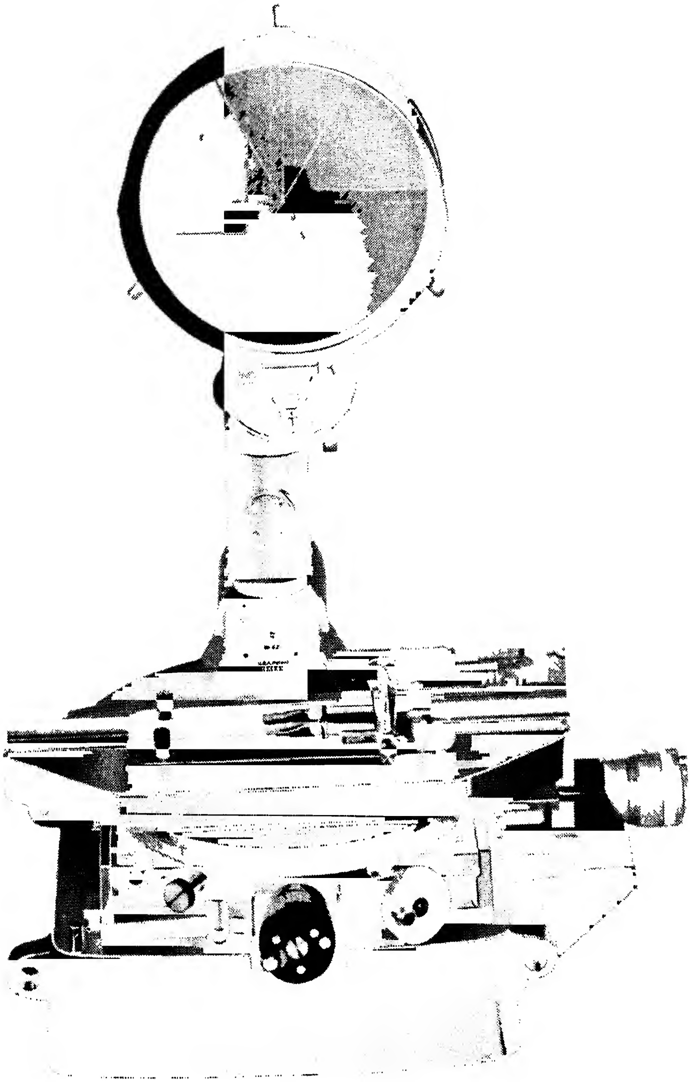


FIG. 18. TOOLMAKER'S MICROSCOPE

[illegible]

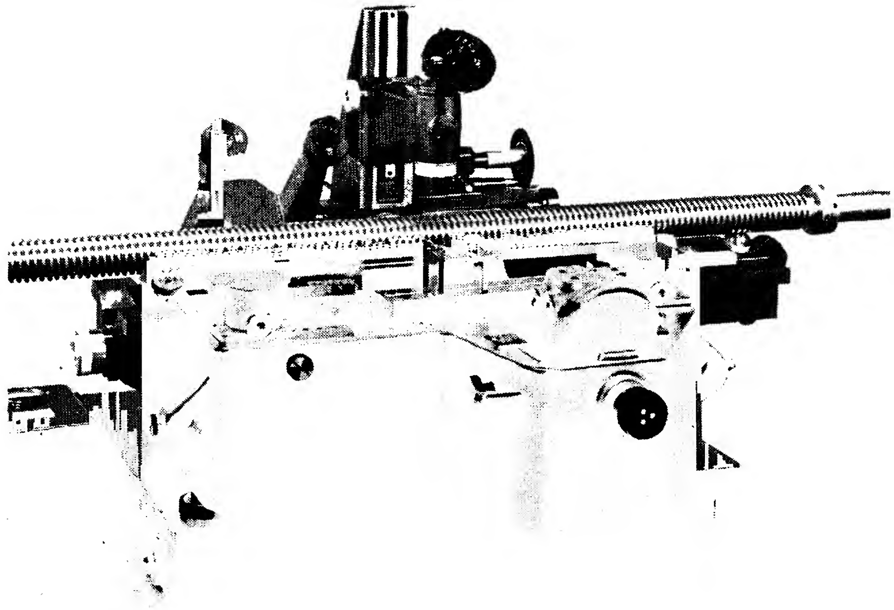


FIG. 19. UNIVERSAL MEASURING MACHINE
(Courtesy of Messrs. Alfred Herbert, Ltd.)

first proof of wear, in the order of 0·00005 in., the gauge may be scrapped, because the workshop gauge would then be passing work outside the limits allowed on the drawing figures.

(At this point it is worth noting that if the attitude be that "a half-tenth of a thou. doesn't matter," then the drawing tolerances must have been mean in the first place.)

To guard against the foregoing, it is correct to make an allowance for gauge wear. Only one or two articles on the subject of wear tolerances have been published, and what is here put forward is the result of many years of effort to evolve a workable practice. An illustration of what follows is given in Fig. 20.

For wear allowance one-tenth of the work tolerance is allowed, with a maximum when the gauge tolerance is above 0·0025 in. Thus there is one-tenth of work tolerance for manufacturing and one-tenth of work tolerance for wear to add to the "go" end of our plug gauge. The wear tolerance is first added, then the manufacturing tolerance; with these, the following would result—

1 in. + 0·001 in./10 = 1·0001 in. = minimum size from tool-room.

1·0001 in. + 0·001 in./10 = 1·0002 in. = maximum size from tool-room.

For the "not go" end a similar manufacturing tolerance is allowed, but in this case we *subtract* from the top limit—because, as was said before, the workshop gauge must fall *within* the work limits. No wear tolerance is required, as (theoretically) there should be no wear on this end of a gauge. Thus, taking the same gauge as before, a 1 in. plug with 0·001 in. tolerance, we get—

1·001 − 0·001 in./10 = 1·0009 in. = minimum from tool-room

and the maximum will be 1·001 in.

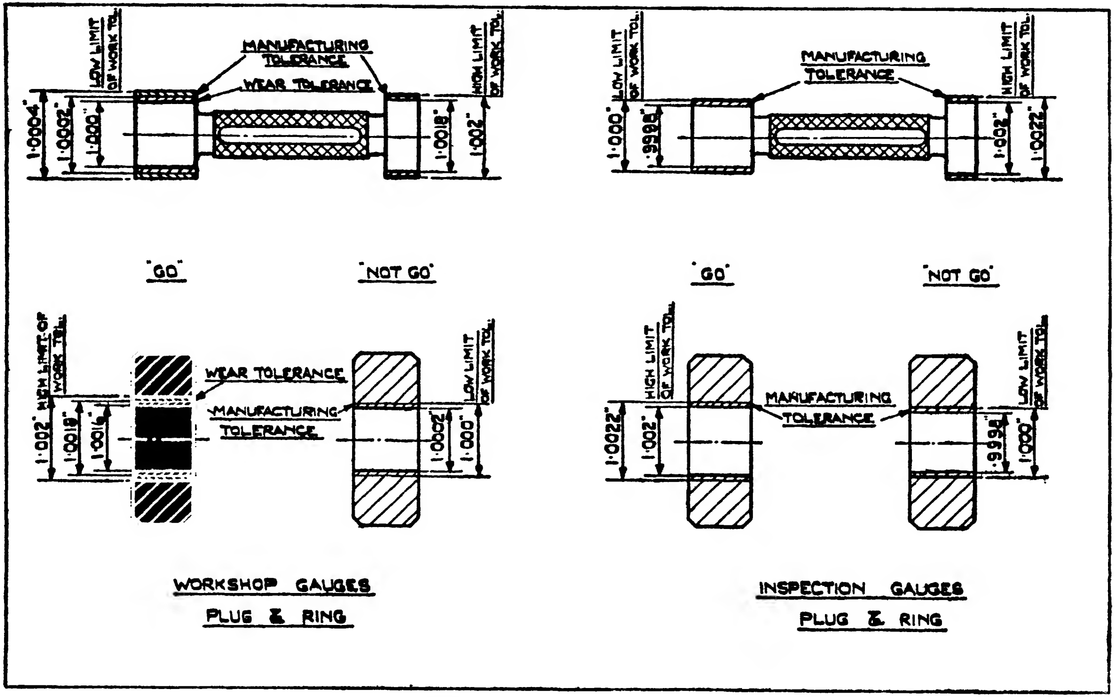


Fig. 20. Theory of Gauge Tolerances Illustrated

WORKSHOP AND INSPECTION GAUGE TOLERANCES

Pursuing the foregoing and applying it to workshop gauges, we have the following gauge tolerances—

Tolerance on Work	"Go" End of Gauge	"Not Go" End of Gauge
0·0005	+ 0·0001 + 0·00005	+ 0·000 − 0·00005
0·00075	+ 0·0000 + 0·000075	+ 0·0000 − 0·000075
0·001	+ 0·0002 + 0·0001	+ 0·0000 − 0·0001
0·0015	+ 0·0003 + 0·00015	+ 0·0000 − 0·00015
0·002	+ 0·0004 + 0·0002	+ 0·0000 − 0·0002
0·0025	+ 0·0005 + 0·00025	+ 0·0000 − 0·00025
Above	+ 0·0006 + 0·0003	+ 0·0000 − 0·0003

In the design of inspection gauges, we have to guard against these gauges rejecting any work parts passed by the workshop gauges. Thus, on the "go" end of the gauge, we subtract one-tenth of the work tolerance and on the "not go" end we add one-tenth of the tolerance (see table at top of page 72).

In many shops, when new gauges arrive they are passed to inspection; but in fact the new gauges should go to the works and the worn gauges go to inspection. For, it is here repeated, inspection gauges *must not* reject work previously passed by workshop gauges if both types of gauge are accurately made.

It will be realized that with adjustable gauges there is no need to allow for wear tolerance, with the result that the gross tolerance is reduced only by an allowance for adjust-

Tolerance on Work	"Go" End of Gauge	"Not Go" End of Gauge
0·0005	+ 0·0 − 0·00005	+ 0·00005 − 0·0
0·00075	+ 0·0 − 0·000075	+ 0·000075 − 0·0
0·001	+ 0·0 − 0·0001	+ 0·0001 − 0·0
0·0015	+ 0·0 − 0·00015	+ 0·00015 − 0·0
0·002	+ 0·0 − 0·002	+ 0·0002 − 0·0
0·0025	+ 0·0 − 0·00025	+ 0·00025 − 0·000
Above	+ 0·0 − 0·0003	+ 0·0003 − 0·000

ment (about 0·00005 in.). This gives the works nearly the full gross tolerance shown on the drawing. For this reason, if for no other, adjustable gap, screw (see Fig. 21), and plug gauges are preferable to solid gauges. On plug and ring screw gauges, wear is more rapid than on plain gauges, and it is recommended that 0·002 in. be allowed for wear tolerance. Because of this there is a tendency to the use of thread calliper gauges; these, in conjunction with the use of periodically inspected ground thread taps of correct size, will ensure accurate threads.

Key and keyway gauges and length gauges should be designed on the same lines as indicated above. It should be remembered, however, that the manufacturing and wear tolerances given are an outcome of personal experience and are in no wise final.

To conclude this section, it is strongly recommended that gauge users ask solid gauge suppliers for guarantees covering manufacturing and wear tolerances, and also that taps, reamers, drills, and broaches be similarly guaranteed.

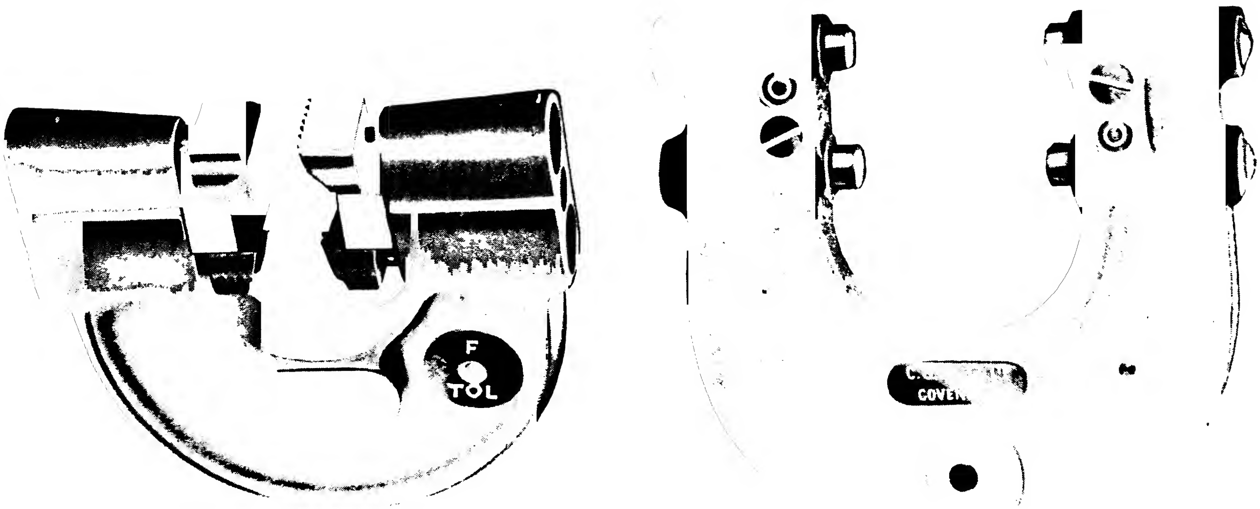


FIG. 21. ADJUSTABLE SCREW AND CALLIPER GAUGES
(Courtesy of Coventry Gauge & Tool Co. Ltd.)

ALLOWANCES FOR GAUGE FITS

One aspect of gauge design not yet covered, so far as the writer knows, is that of gauge fits in holes and ring gauge fits on shafts; the latter, with the general acceptance of adjustable calliper gauges, is not of much importance.

With a perfectly round gauge and a perfectly round hole of good finish (freedom from tool or from wheel marks), a 1 in. plug gauge will enter a 1 in. hole. With holes other than the kind mentioned, no entry can be made without forcing. But, apart from this, it is generally true to say that for free entry of a "go" gauge and for fair reading of what is a moderate fit, some allowance should be made if too much of the work tolerance is not to be taken up by wear tolerances, manufacturing tolerances, and *gauge-fit tolerances.*

For example, if on a ground hole 0·0002 in. is required for the gauge to go in comfortably, then this 0·0002 in. is, in effect, a reduction of gross work tolerance. It is thus suggested (somewhat diffidently) from experience that the following is fair practice: On bored holes allow 0·0001 in. per 1 inch of diameter up to 6 in. and add 0·00005 in. for each inch above. For reamed holes allow 75 per cent of the foregoing, and for finely bored, ground, and lapped holes about 50 per cent.

The foregoing, in effect, will mean that our 1 in. gauge will have, if used on a bored hole, for wear tolerance 0·9999 in.–1·0000 in., and for manufacturing tolerance 1·0000 in. – 1·0001 in.—a reduction of 0·0001 in. and an increase of workshop tolerance by 10 per cent. This, if accepted, is true of all previous examples given.

THE PROBLEM OF FINISH

One has only to suffer for a time the terrible vaguenesses of aircraft and some other inspectors on what is a satisfactory finish to realize the need for some method whereby

finish may be measured. So far, our ideas on finish are usually expressed in terms such as "rough," "commercial," "polished," and "mirror" finishes, and the interpretation of these terms is left to inspectors' and others' sight, comparative sense, thickness and thinness of finger-nails, the state of the surrounding light, and the astuteness of wily foremen to get things past.

It will generally be agreed that the surface produced by, say, ordinary turning is made up of valleys and hills. If there were no valleys and hills, a perfectly smooth surface would exist. Now, when two ordinary turned surfaces meet, as in a bearing assembly, the tops of the hills take the greater part of the pressure. With normal pressure in the bearings, the hills will, in time, give way and the bearing clearance be reduced.

Initial wear, it is usually accepted, depends to a large extent on the roughness of the bearing surfaces, and, in general, the higher the hills and the lower the valleys on the bearing surfaces, the greater the initial wear. To put it another way, the less the hills and valleys, the greater the surface contact and the better the distribution of pressure.

It seems that the usual order of fineness of finish under normally good conditions is as follows, with the fourth as the best finish: (1) reaming, (2) grinding, (3) fine boring, (4) honing after fine boring; but as each of these processes may produce varying surfaces (although gauge readings may show the same dimensions), it yet remains to define what is a satisfactory finish for any job, and further, so to define it that it is factual.[1]

MEASUREMENT OF FINISH

Various attempts have been made to measure "finish." Zeiss have developed a microscope which by projection of light gives a line following the contour of the metal. Chrysler

[1] See page 77.

in America have developed a profilometer, and Shaw in Britain has developed a contorograph.

It is not here suggested that the correct thing to do is to purchase a surface-recording machine; it is, however, suggested that it will be of assistance to most engineering companies to have records taken of what seem typical satisfactory finishes, then to mount samples in the shops with a statement against each sample of how it was procured, type and shape of tool, feed, speed, and coolant. Whether or not surface records be taken, the mounting of samples will help, not only in the direction of reduction of initial wear, but also in that of elimination of part breakages under load because of surface scratches.

The most effective finish is not one which will give 100 per cent surface contact; thus the surface contact between two "wrung" standard slips is about 75 per cent and on a "finely ground" surface about 25 per cent. Problems of oil retention, for example, limit the use of the perfect surface (if such is attainable), and the advantages of cold working, such as takes place when a turned rough surface contacts another surface under pressure, must be considered.

FINISH AND TOLERANCE

But, whatever be the finish desired, it should be the subject of more than verbal or written symbolic treatment, as on a drawing. It is absurd for experts to talk of manufacturing tolerances of "two-tenths of a thou." and wear tolerances of a tenth of this two-tenths if, at the same time, surface finish be not specified correctly. The following example will illustrate this point—

On electric screen-wiper motor production on a continuous basis, the dimensions for rotor shaft and bearing holes were identical (0·2 in. ± 0·0001), and selective assembly was used. When reaming, then reaming plus burnish broaching was used, a rotor which was a good fit at the beginning of assembly

Form No. 24

MEASURING INSTRUMENT INSPECTION CARD

No.

Description: Department: Date Issued: Inspection Period:

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	5.

Date	Condition of Instrument	Inspected by	Date	Condition of Instrument	Inspected by

FIG. 22. MEASURING INSTRUMENT INSPECTION CARD

was often too "sloppy" at the finish of assembly (comprising about twenty minutes' running). When a type of lapping was introduced this trouble was eliminated.

Note that in the foregoing example shaft and bearings were correct to gauge sizes before assembly. The moral is: type of finish is of equal importance to dimension, and if one is specified so should the other be specified.[1]

GAUGE CONTROL

All measuring instruments should be subjected to some such planned inspection as follows—

On return from use: All gauges and micrometers (and jigs).

Weekly: Operators' micrometers—if these are allowed; tool-room and tool stores comparators, microscopes, and projectors.

Inspectors' gauges kept on inspection benches.

Three-monthly: Workshop slip and length gauges used by inspectors for gauge setting and checking.

All gauges and instruments should be numbered and a card opened for each one (Fig. 22). Where possible, the inspection period should be budgeted and the card should be ticked each time inspection takes place; if something is wrong with the gauge or instrument, this will be recorded and the card kept in a suspense file until the instrument is put right or is replaced.

[1] An American proposed specification gives as root mean square height of irregularities—

Rough machining (clearances)	0·004–0·063 in.
Turn, bore, and mill	0·000063–0·001 in.
Grinding and honing	0·00008–0·000032 in.
Fine grind and hone (gauges)	0·000001–0·000004 in.
Laboratory work	0·00000025–0·0000005 in.

CHAPTER X

HOW MUCH INSPECTION?

WHEN we come to analyse inspection we are, apart from the usual somewhat academic statements one reads, on quite new ground; note that we say "analyse," and not merely "state the principles of" inspection. Thus one finds it said that for certain products, inspection should take place after every operation, that only the first one off each operation should be inspected, that x number of parts per $x + y$ number operated upon should be inspected (selective inspection), and so on.

In fact, the application of inspection to a part will depend, as we shall show later, on the probability of scrap being made at any operation, on operation labour costs, machine-rate cost, material cost, cost of inspection, and the function each part has to perform in terms of whole-product performance.

INSPECTION EFFECTIVENESS ANALYSIS

If one is asked to make a survey of inspection effectiveness, an approach could be made as follows—

1. Make a study of the fitting of the most standard product as a test of inspection effectiveness.

2. Make a job analysis of one or more inspector's tasks for one day.

3. Consider in terms of product and of product flow whether decentralized or centralized inspection is the better. Show this on a lay-out, paying particular attention to heavy work and the operations on this work.

4. On the most standard product, list out all operations

(against a parts list if no route cards (see Chapter XX) are in existence); note present inspection technique, and put against this a planned inspection technique (see page 84).

5. Consider the present inspection routine as it affects inward material, and the booking of good, questionable, and bad material in conjunction with the transfer of the booked information to stores, purchasing, planning, and accounts.

6. As above for material in process of manufacture, with transfer to stores, planning, and costing of booked information.

7. As above for assembly and for final test.

8. Consider the responsibility and authority of chiet inspector and of each member of his staff.

9. Inspection costs.

THE FITTING SHOP AS A TEST OF INSPECTION EFFECTIVENESS

The writer can quote more than a score of cases of engineering companies, some of them nationally known, where the introduction of effective inspection routines saved from 25 to 90 per cent of fitting shop direct labour cost. This undoubtedly is a startling statement, but in fact it does not seem so when one considers the methods used in what may be called the average engineering works.

The analysis given on page 80 of the assembly of a product illustrates from practice the results of effective and ineffective inspection.

The foregoing difference in time resulted *only* from correct gauge control and effective inspecting procedure. Similar, or nearly similar, instances could be quoted for electric motors, pumps, machine-tools, hoisting machinery, internal

combustion engines, and other products. The moral, though not a generally applicable one, is—

If you want to know how effective your gauges and your gauge uses are, make an analysis of fitting shop method.

Before Inspection Organization	Sec.	After Inspection Organization	Sec.
Get job	214	Get job	201
Prepare	209	Prepare	281
Fit key on shaft (1)	1307	Assemble shaft (1)	221
Fit wheel (1)	877	Assemble shaft (2)	233
Fit key on shaft (2)	946	On journals	275
Fit wheel (2)	905	Assemble shafts in case	292
Journals on shafts	612	Assemble case	247
Scrape 2 bearings (1)	1305	On fan	112
Scrape 2 bearings (2)	1121	On cowl	123
In shaft (1)	311	Miscellaneous	241
In shaft (2)	471		
Assemble case	980		
Fit fan	432		
Fit cowl	611		
Miscellaneous	1771		
	12,072		2,226

It is true there may be too much gauging, as will later be seen; but this is less common than are no tolerances or wrong tolerances, shortage of gauges, wrong gauges, and badly made or worn gauges, either too little inspection or inadequate use of the existing inspection staff, and, last but not least, lack on the part of the directorate to comprehend the place of the quality control function within the organization.

TYPICAL ANALYSIS OF AN INSPECTOR'S JOB

The following result of a study of an inspector had four objects—

1. To find out the gauges used.
2. To get inspection times on certain types of work.

3. To study inspection skill utilization on separate jobs.

4. To find out the actual inspection cycle as a percentage of the day's total cycle.

Only the last of the four is illustrated here.

	Total Time	Sec.
1.	Take over from night man	420
2.	Removing scrap	282
3.	Consultation with foremen, operators, etc.	1,380
4.	Handling instruments	833
5.	Consultation with and assist other inspector (new)	6,165
6.	Handling drawings and planning sheets	194
7.	Perusal of drawings	659
8.	Placing work on bench for inspection	760
9.	Arranging and preparing work on bench	280
10.	Stamping inspected work	280
11.	Go to A.I.D. for special gauge	735
12.	Making out scrap notes	145
13.	Making inspection records out	1891
14.	Making extra operation notes	374
15.	Attaching tags to work	346
16.	Put work on floor after inspection	748
17.	Wipe hands	255
18.	Go to final inspection office	510
19.	Tidy bench	121
20.	Go to tool stores for gauges	1253
21.	Consult chargehand inspector	1061
22.	Search for chargehand inspector	130
23.	Put tackle away	140
	Miscellaneous	504
24.	Get paint	22
25.	Take paint back	20
26.	Making tags out	166
27.	Talk to progress man	67
28.	Get wire from drawer	11
29.	Read notice sent to all inspectors	24
30.	Hang tags on nail	6
31.	File notice	38
32.	Pin notes up	10
33.	Paint rejects	5
34.	File inspection notes	10
35.	Peruse scrap note	23
36.	Mark with pencil	68
37.	Get hammer	8
38.	Look for punch	26
39.	External micrometer	3162
40.	Internal micrometer	182
41.	Thread gauge	111
42.	Plug gauge	306
43.	Depth gauge	771
	Carried forward	24,502

		Sec.
	Brought forward	24,502
44.	Special radius gauge	445
45.	Taper ring gauge	59
46.	Protractor	180
47.	Vernier	620
48.	Callipers	647
49.	Rule	1515
50.	Examine ends of shafts	114
51.	Examine for finish	397
	Total	28,479
52.	Re-mic. passed work	113
		28,592
	Waste Time	1781
(*a*)	Total actual inspection time	8622
(*b*)	Total non-inspection-time	19,970
		30,373

Inspection time = 28·4 per cent.

FOR AND AGAINST CENTRAL INSPECTION

It is equally wrong to have line or bay inspection merely because it saves material handling, as it is to have centralized inspection merely because it means lower direct inspection cost. The problem is greater than is indicated by either kind of reasoning.

Thus, in a big shop with ten process inspection stations and one final inspection station, inspection gauges for full effectiveness should be multiplied eleven times—either that, or inspectors will have to go for gauges and, perhaps, not always find them. Again, the making and keeping of records will be decentralized, control will be more difficult, the decentralized inspector is too apt to be influenced by his isolated contact with producers, and, finally, there is little likelihood of the inspector's skill and experience being properly utilized. The last point is an important one, for, in the non-continuous production shop, at one period the inspector may be exerting full skill on examining, say, worm gear, and in the next period be examining ½ in. Whitworth screws with a 0·009 in. tolerance.

In most engineering shops the advantage of dotting single inspectors up and down the shop is a shadowy one. It is true—

(*a*) that operators may not have so far to walk with their "first one off";

(*b*) that inspectors may not have so far to walk to examine heavy parts on site; and

(*c*) that finished parts may not have to be trucked so far; but, in fact, these, when analysed, seldom assume the costs importance given to them in the first place.

It is not here suggested that either decentralized or centralized inspection is in itself ideal for any particular shop—it is suggested merely that all of the facts be considered before a decision is made.

Travelling inspection is often used where it is unnecessary, and vice versa. The idea of having an inspector moving continually and consistently through a department examining work is sound in principle where close-limit work is done on machines likely to vary in output accuracy because of mechanical, human, or other factors; but batches of similar work must be large enough, or operation times long enough, to ensure periodical inspection. Travelling inspection as usually practised, however, is inclined to be accidental in time and in place, and may not be applied where it is most needed within a department. The alternative in many cases is planned inspection.

WHY NOT PLANNED INSPECTION?

It is a peculiar fact that the planning applied to finance, costs, processes, and material by academic writers on management is seldom applied to inspection. Yet it will readily be agreed by engineers that all products do not merit inspection after every operation, just as some products do merit it and deserve more than sampling. The following example will illustrate the point—

Special Bolt

First operation: turn end, screw, and part off in capstan.
Second operation: drill pin hole, using jig.

This job had a scrap record of less than ½ per cent on the first operation, and the second operation cost 0·04d. each for labour, with machine rate 0·06d. each. Inspection of first operation cost 0·16d. each, of second 0·09d. each; of both together 0·18d. each.

With a lot of 200 off, the first operation inspection would probably find one scrap at a cost of about 2s. for inspection; if there were no inspection, the second operation cost would increase by 0·04d., and inspection would save, by inspecting only after the second operation, about 0·07d. each part.

In fact, planned inspection processed the inspection of this job to an apprentice and saved, not 0·07d., but about 0·19d., a saving of 80 per cent.

The same kind of reasoning may be applied to shafts turned for plunge grinding or even for ordinary grinding, milled articles to be later jig drilled, rough-turned parts which are not followed by a highly expensive operation, drill and tap operations (the tap determines tolerances), and the like.

The planning of inspection is done on the route card (Fig. 55, page 199) after the operations are planned, and the inspection instruction goes on the operator's job note.

BASIS OF PLANNED INSPECTION

Planned inspection usually insists that—

1. The first one off on any job be inspected.
2. A change-over from one shift to another on most jobs requires that the first one off on each shift be inspected.
3. A change of tools or the grinding of tools on certain jobs requires that the first one off with the altered tools be inspected.

4. A split batch done on two or more machines requires that the first one off on each machine be inspected.

5. A batch of, say, 100 of an expensive job on which previous operations were expensive requires that 1 in 5 or 10 or 15 or *x* be inspected if the probability of scrap work on the expensive operation in question be high.

6. In general, all parts require inspection before assembly.

7. All assembled units be inspected to standard instruction sheet before test.

8. The type, application, and duration of final tests be planned, and that test inspection sheets be planned to ensure adequate inspection at each necessary point, and that responsibility for good or poor inspection be properly recorded.

Further, that—

9. The inspection of material inwards be on a planned basis (see Chapter VIII, page 59).

INSPECTION ROUTINES

In over a score of engineering works the writer found inspection engaged on making records for from 6 to 10 per cent of the working day. Yet in very few companies is there the necessity for the inspector to do any writing other than to record quantity good, to be rectified, and to be scrapped on the job note. All other records, scrap notes, rectification notes, and departmental summations can be made out by a clerk in the inspection department—given, of course, that inspection is centralized.

The normal routine of inspection recording covers inward material, work in progress, and finished materials, and may be listed as follows—

Inward Material. Inspect to specification and record results on material inwards note (Fig. 28, page 105). Inspector may take brinell reading (as on forged billets), and laboratory take a hot etching and a constituents test.

Work in Progress. Inspect to drawing and record results on workers' job note or on inspection note. If on job note, this goes to planning, then to costing; if on inspection note, a copy is kept on inspector's file and the original goes to planning and a copy to costing; note that the information will be transferred to the job note. If there is a route tag with the job, the inspector alters the quantity received by deducting the quantity—if any—scrapped. If a part requires rectification, it is usual to have this done at once, if it is feasible to do so, to enable the job to go forward as planned.

Parts requiring either rectification or scrapping are marked with coloured chalk or paint where wrong, and a note is made out for each group of like parts to be rectified, a scrap tag being attached to each group of like scrapped parts. A scrap tag and a rectification tag are both shown in Fig. 23.

SCRAP

Order:	Part:
Pieces good:	Scrap:
Man's No.:	Machine:
Cause:	

Cost against:
Date:
Insp's Sig:
Job to be held up for replacements:
Job to go on and replacements to follow:
No replacements:
Date:
Planner's Sig.:

RECTIFY

Order:	Part:
Pieces good:	Scrap:
Rectify:	Cause:
Man's No.:	Machine:

To be rectified by:
Cost action:
Date:
Insp's Sig.:
Job to be held up for parts rectified:
Job to go on:
Date:
Planner's Sig.:

FIG. 23. SCRAP AND RECTIFICATION TAGS

Assemblies. Electrical sub-assemblies, e.g. stator coils and armature coils, should be tested and labelled "O.K." before assembly; so with armatures and stators—these should be tested before and after dipping. Mechanical sub-assemblies are generally inspected before final assembly if they are operated upon by labour other than final assembly labour, or if they go into stores before final assembly. For electrical sub-assemblies, a special test tag is best; for mechanical sub-assemblies, if they are not run under test, the ordinary inspection note is sufficient.

As with sub-assemblies, so is it with assemblies, but it is usual to distinguish between final testing and assembly inspection.

Final Testing. On machine tools, electric motors, dynamos, switches, and the like; pumps, gear clusters, and cased gears; printing machinery, mixing plant of all kinds, and the host of other active mechanisms produced by engineers, it is usual to have a standard form of test which, to some extent at least, duplicates actual conditions of service. In many shops not enough attention is paid to this final test, the major faults being—

(*a*) the tests are not comprehensive or thorough enough,

(*b*) the tests are not strictly standardized, and there are no records showing in detail the performance of the product.

Final Inspection. The final inspection of the completely tested and painted product is important. This inspection should be against copy of the order, and nameplates, special pulleys, and other detail should be carefully checked and ticked off on the copy order if correct; finish should also be checked, and, if possible, the mechanism should be operated, if only by hand, to ensure that there is no interference. The test sheet written of above may be designed to cover this final inspection, and special detail may be transferred to it

by the drawing office or by the order department: in this case the copy order will not be required.

INSPECTION AUTHORITY AND RESPONSIBILITY

It should be realized that—

(*a*) It is not the function of inspection to produce good work; it is the function of inspection to assist, by the application of standards, the production of good work by insisting that no part of a product which does not meet the standards set will pass to the customer. Thus, the inspector's function is finally that of customer service.

(*b*) Having inspection under the control of a production executive is liable to lead to the easing of necessary standards to suit costs or delivery needs.

Both of the foregoing principles require positive recognition, especially in small engineering works. It is reasonable to have inspection under the control of the general manager or, in large works, the technical director: in no case has the writer found inspection to function really effectively under the works or the production manager.

Last, but not least—

(*c*) The long-time effect of bad delivery is not so drastic on a company's welfare as is that of bad workmanship. Too often the standards of inspection have to be modified because of this or that production or financial factor. If inspection is to be responsible for the passing only of work up to standard, it should have equal authority to reject work not up to standard, and to stand out against the production and financial departments on an equal footing with these departments. If appeal to the higher executive must be made, let the production and financial departments make it—this way is the way of good engineering and good customer service.

COSTS OF INSPECTION

As a general guide, the following ratios may be useful; gauge and tool inspection is not included.

Machine tools	1 inspector per 30 direct employees
Small tools (including jigs)	1 inspector per 22 direct employees.
Hoisting equipment	1 inspector per 40 direct employees
Electric motors (excluding test-bed)	1 inspector per 32 direct employees
Transmission equipment (including gears)	1 inspector per 25 direct employees
Pumps, etc.	1 inspector per 36 direct employees

The general figure for engineering seems to run at about one inspector per 30 employees; in shops where fitting and not assembling is the rule, one inspector per 70 direct employees is not unusual—this mostly in small shops. It should be noted that the ratios given are for batch production and special production shops with machine and fitting shops.

Inspector supervision by executive inspectors is a question which arises only in the large shop employing nearly or more than 1000 people in the works. The writer has found that the very nature of the inspection task is such that every six or seven inspectors require a divisional chief responsible to the chief inspector.

On aircraft work variations are very considerable, ranging from 1 inspector to 5 machine-men to 1 to 20. On precision engineering details 1 to 12 is reasonable; on general engineering details 1 to 18 is reasonable; the former for such details as gears with short operating times. On continuous production with inspection instrument set-ups 1 to 22 seems reasonable. Arithmetical definition of finish, planned machine maintenance, rigid gauge inspection, and intelligent supervision combined with planned process inspection, plus bench inspection after most operations, are necessities, not generally recognized, on aircraft engineering work.

CHAPTER XI

THE PURCHASING ORGANIZATION

So far as we are concerned, the purchasing department has not the responsibility for material control and store-keeping (see pages 107–122), for, it seems, because of the vital contacts between material control, stores, and the planning department, modern practice suggests that the responsibility be the planning executive's.

PURCHASING ORGANIZATION EFFECTIVENESS ANALYSIS

We are not here concerned with the economics of purchasing, but with the practice: in terms of this will be our analysis.

In the chapter on Material Control we deal with the necessity for (*a*) stock lists of direct and indirect materials normally kept in stock and (*b*) the technique of requisitioning and the distribution of authority on who shall requisition the stores and the buyer. These, therefore, we need not touch upon here.

In the writer's experience, the chief criticisms to which purchasing is open are—

1. Under-estimation of the money value of a good buyer (i.e. the value of characteristic shrewdness, courtesy, and tact).

2. Division of responsibility to buy—this usually in small and moderate-size businesses.

3. Division of responsibility to interview potential sellers of goods.

4. Not enough use of sellers' ideas.

5. Lack of competent records of past, present, and future suppliers, and of supplies as such.

6. Poorly indexed catalogue system.

7. Lack of effective outside supplies follow-up system.

8. Ridiculous materials delivery dates asked for by production and drawing departments (owing to poor planning).

9. Ordering too much material owing to lack of stores records on material turnover.

10. Bulk ordering of material when, if jobs were scheduled and planned, bulk orders could often be split over two or more months.

11. Difficulty in getting information from works departments on material performance.

12. Lack of accurate specifications from drawing office.

THE REQUISITION

The requisition on the buyer should, for stock material and for such special material as is mentioned on page 101, come only through stores.

For the requisitioning of special material a defined form should be used, and the kind and type of material, plus such mechanical and chemical detail as is necessary, should be stated (see page 103).

For his own sake the buyer should carefully note the date of receipt of the requisition on the back thereof and should file it under quotations asked for. When the order is placed, the copy requisition should be attached to the buying copy of the order, or requisitioning details should be copied on the back of the order.

ORDERING TECHNIQUE

It is usual in general engineering companies to have orders in quintuplicate. Where orders approach 50 per week, continuous stationery may economically be used on a billing machine.

The distribution of the order is usually as follows—

Original: Sent to supplier.

First copy: Purchasing permanent files.

Second copy: Purchasing loose file for progressing.

Third copy: Stores copy.

Fourth copy: Receiving department copy cut away to show only description and supplier.

The purchasing loose copy may be omitted if the supplier's index card (Fig. 24) is used for progressing.

The stores copy is used for passing on to balance-of-stores record (Fig. 30, page 108), the receiving department copy is used as an indication of source and kind of material and is sent back to the buyer with a copy of the goods forward note (Fig. 28, page 105), and the buying department copy is used for checking the supplier's invoice before passing the invoice for payment.

RECORD SYSTEM

The main records in the purchasing department are—

1. Supplier's record card (Fig. 24).
2. Commodity record card (Fig. 25).

Both records are necessary, the first as a record of price, and the second as a reference to suppliers of a particular commodity and as a commodity price and discount record. The buyer refers to the latter when about to place an order without quotation.

If the supplier's record card be mounted in a "visible" card cabinet, the bottom of the card may be date-printed for progress signalling, and, if kept in a box file, the top may be similarly dated. In both cases coloured celluloid signals can be used.

It will be noted that the card shown in Fig. 24 has columns for notes on delivery and quality service. This latter is entered up from service records initiated in the works by the buyer, and is very useful for belt, drill, tap, diamond,

SUPPLIER'S RECORD CARD

Date	Order No.	Description	Matl.	Quan.	Date Reqd.	Ackd.	Dely. Conf.	Progress Record	Dely. Recd.	Performance and Quality Record			
										Delivery			Nature of Complaint (if any)
										Early	To Time	Late	

Supplier's Name:

Days: 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 | 1 2 3 4 5 6 7 8 9 10 11 12

FIG. 24. SUPPLIER'S RECORD CARD

Form No. 057

COMMODITY RECORD CARD

Order No.	Date	Supplier	Description	Price			Discount
				£	s.	d.	

FIG. 25. COMMODITY RECORD CARD

and similar material service records and for notes on faulty materials generally.

It is essential, however, that the buyer, if he desires to have service reports from the works, should ask not merely for a report, but for a report covering all of the factors involved. Indeed, if the report is not to be biased or made up for convenience, it is best put in the research department's care, or in the care of the planning department.

Over and above the foregoing the buyer should have records of any variation in tin, copper, and tungsten prices. He should have copies of the direct and indirect materials stock lists (page 100), of the standards book (page 57), and of all buying specifications.

CATALOGUE FILING AND INDEXING

A good stock of catalogues is of considerable service to an engineering company, and, in spite of practice to the contrary, there is no reason why the catalogue stock should not be full and up to date, neat, and effectively indexed.

Catalogues and the like are best filed according to size numbered, and indexed by numbers from (*a*) a catalogue, record card by commodities, and (*b*) catalogue suppliers' names record in alphabetical order. Leaflets can be kept in envelopes.

A diarized record of all catalogues loaned from the department should be kept, and a maximum period allowed for use.

The buyer or an assistant should scan all trade journals of commercial interest to him for offers of new catalogues. This is good buying.

COST OF BUYING DEPARTMENT

Various authorities advocate a ratio of buying department expense to sales value; but this, though it may be correct, may also be very wrong. Indeed, the writer has a score and more actual buying/sales value ratios for

engineering before him, and though he knows buying is effective in each case, the ratios are "all over the place." So, too, with cost per outward order handled.

For six engineering companies on medium and small batches of a moderately standard product (i.e. subject to special changes, as special feet on motors), buying department costs range very close to 0·45 per cent of value of goods bought.

For five engineering companies on medium and small batches and one-offs of two or more products subject to special variations, buying department costs are much higher than the previous ratio given, ranging from 0·65 to 0·75 per cent of value of goods bought. This includes all charges and progressing of outside material.

These ratios are indicative only; each company should search for and use the ratio which suits it most.

CHAPTER XII

EFFECTIVE MATERIAL CONTROL

WHEN one looks for a definition of material control which fits in with practice, it is somewhat difficult to find one suitable. Thus, the *Cost and Production Handbook* says that "Material Control at theoretical perfection is the provision of the required quantity and quality of material at the required time and place, with the minimum investment possible."

DEFINITION

Far from the foregoing being a statement of perfect material control, it might by some material controllers be regarded as very imperfect. In many businesses material control includes close keeping of records of use and of service, as when a controller keeps records of expensive grinding-wheel use, of diamond use, of lamp use, and, in general, of use of indirect materials. In some works the drawing office and the production office control use of direct materials, and the accounts department insists on the materials department (or stores) controlling the use of indirect material and material salvage.

Material control is the provision of the correct kind, quality, and quantity of material at the required time and place, the testing of this material, and the recording of the use of such material with a view to controlling it in terms of a budget, either stated by the design or the planning function (direct material) or derived from experience or from recorded observation of its use (indirect material).

The confusion of material control with direct material control only, when in fact material control is a function expressed by drawing office, planning, progressing, and

stores, leads to bad practice; thus, the materials list or parts list is usually stated in some publications to be the formal basis for material control, with consequent omission of control of indirect materials or, as they are sometimes called, "consumable stores." Consequently it is not unusual to discover that while control of direct material is often fair to excellent, control of indirect material is more often bad to fair in the same works.

A case in point comes to mind. One large engineering business had really effective control of direct materials; but stationery, welding, laboratory, photographic, and some other materials were not indexed on control cards. It was argued that the cost of controls would not be justified for these materials when in fact the turnover in money of the materials was as great as the total material turnover for an engineering company employing nearly 100 people.

The large company, by reason of its size, is apt to lose perspective—in indirect material control perhaps more than in other activities.

INVESTIGATING MATERIAL CONTROL

For thorough investigation of material control, the procedure might be as follows—

(*a*) *Direct Materials*

1*a*. Who initiates purchases? Classify people and departments who requisition on buyer and note materials required by each.

2*a*. Flow of requisitions. Do all requisitions bear stamp of material control department?

3*a*. Purchase follow-up technique.

4*a*. Technique of material receipt: checking forms used, flow of forms, recording.

5*a*. Who initiates material release from stores? Classify as above.

6*a*. Is parts list, materials list, or requisition used?

7*a*. Method of parts or materials list statement, i.e. parts listed for ease of checking and of issue. Are quantities of materials, castings, stampings, bars, sheet, tubing, etc., shown so as to aid correct issue?

8*a*. Stores check off against parts or materials list: method and accuracy.

9*a*. Is a record kept of each stock part?

10*a*. Design and type of record. How and by whom kept? Control quantities shown?

11*a*. Check recorded quantities against actual quantities in x cases.

12*a*. Is provision for reserving material against new orders made on cards?

13*a*. How are obsolete and slow-moving stock shown?

14*a*. What is effectiveness of contact of planning with material control division as to exchange of information on shortages, material required in future, and material released to shops; and with drawing office on use of slow-moving and obsolete materials, odd pieces, and the like? What forms are used for this?

15*a*. Are there standard allowances for parting-off bars, and for forgings? If so, does drawing office include this allowance? Or does stores include it?

16*a*. Check up on bars in shop against quantity recorded as issued.

17*a*. Are production departments debited with excess material issued? How and by whom? How and when is this material returned? How recorded?

18*a*. What standard technique is used in the works to ensure non-mixing of, say, bronze and cast-iron swarf, or nickel and mild-steel swarf?

19*a*. What is technique of unlike-swarf separation?

20*a*. What steps are taken to salvage short ends and usable scrap?

21*a*. What is stores technique for recording shop scrap and lost parts, and for informing departments concerned?

22*a*. Speed and accuracy of stocktaking: periodicity of stocktaking.

23*a*. Frequency and extent of checks of recorded material against actual.

24*a*. Material control costs.

(*b*) *Indirect Materials*

1*b*. Initiation of purchases—as 1*a*.

2*b*. Flow of requisitions—as 2*a*.

3*b*. As 3*a*, 4*a*, and 5*a*.

4*b*. In how many places is indirect material stored: works, maintenance, publicity, stationery and other materials?

5*b*. What records are used of indirect material use in each stores place, if more than one place?

6*b*. Is there any example where the users of material are in control of material, or is control centralized?

7*b*. Are there control ratios for use of each important kind of indirect supply?

It will be noted that we have not touched upon the design, drawing office, or planning aspects of material control. These are dealt with elsewhere in the book.

THE NEED FOR A STOCK LIST

Standardized practice in the requisitioning or buying department is very much worth while. The first consideration is, who shall requisition?

Most organized companies have a stock list which gives all of the material normally kept in stock, and it is generally accepted that what is not on the stock list should not be requisitioned by the material or the stores department.

All standard castings, pressings, billets, and stampings are listed as stock, all bars, bolts and nuts, and other material that can be machined for use on standard or special

products are listed as stock, and all electric bulbs, oil, waste, and other indirect material normally used in the shops are listed as stock. But while ball races of a standard size will be listed as stock, those of a special size will not be so listed; while bright bar from $\frac{1}{4}$ in. to 3 in. may be listed as stock, $7\frac{1}{8}$ in. bright bar may not be so listed.

But it is noticeable that such stock articles as pencils, paper, electrical repair items, standard drawing office requisites, coal, coke (for forge), packing materials, and chemicals for laboratory are not listed as stock. In only one company out of a few score worked with has the writer found items like the foregoing listed as stock, and that company had no control records for such items.

It is essential that every company should have a list of all stock items, and that the use of records for control of the purchase and use of all such items be considered. It is further suggested that the control of all records be vested in a central authority, even if the actual issue of stock be not under centralized control; on the other hand, stock issue should not, in principle, be under the control of the user of the stock.

The foregoing suggestion could be taken up with profit by most engineering companies. A useful approach to listing stock items can be made through classification (see Chapter V).

WHO SHALL REQUISITION THE BUYER?

It follows from the foregoing that all stock items will be requisitioned on the buyer by the material control or the stores department on the basis of recorded needs in terms of orders in hand and balance in stock. But who shall requisition special materials not listed on the stock sheet?

The writer has found it worth while to list all the people who requisition the buying department, and to compile lists of materials usually treated as special. Often enough one finds requisitioning somewhat irresponsible. It is

sometimes recommended that a list of all unused special parts (such as special ball races) and of obsolete stock be kept in the drawing office; but, in fact, the list if so kept does not seem to fulfil its function. It is more effective to pass requisitions for special material over the material records; this applies to special ball races and to special bar and billet material more than to, say, special castings and stampings.

Leaving aside for the moment machines and tools, there arises the further problem of the routine of passing requisitions for non-stock material to the buyer from the user. It is worth while stating rules as to who shall requisition the buyer, what each person shall requisition, and to what value.

THE REQUISITION

The design of the requisition on the buyer will depend upon the type of organization set up, and it is advisable for the reader not to copy the requisition form shown in this or any other book. Quite recently the writer found a large engineering company using a purchase requisition which was justified because it came from an excellent book. The requisition copies (two) were sent to the receiving department and the stores record department respectively, and a copy was not sent to inspection, with costly results, for sometimes a copy of the goods inward note was sent to inspection and sometimes it was not.

SPECIALS REQUISITION

The requisition shown in Fig. 26 is for special materials but is not used for stock materials or for productive machinery, office equipment, and the like: these latter require a special form.

One copy of this requisition is kept by the originator, and two copies go to the buyer. The buyer gets a quotation and, if requested, fills in the prices and other terms, and

No. 6666

PURCHASE REQUISITION

To buyer from dept. Date:

Please order (get quotes for) the following material to Specn. No.

to be delivered here on . Order No.:

Description:

To be charged to . Quantity: Unit:

Quotes to be sent to Messrs. (1) (2)

(3) for approval with copy of this requisition.

Signed:

No.	Quote from	Price	Discount	Delivery Terms	Delivery Promise	Terms
1						
2						
3						
4						
5						
6						

Ordered from No.: Date: Reason:

Order No.: Terms:

FIG. 26. PURCHASE REQUISITION

(In triplicate: one in originator's file, two to buying department.)

sends one copy to the people nominated as approvees on the requisition, or to such people as standing orders define as approvees; the other copy he files against the return of the copy sent out. When the originating department receives a copy of the order, the requisition may be in duplicate.

STOCK REQUISITION

The second requisition shown (Fig. 27) is for stock materials, and is originated in the stores or in the material control section of the planning department. One copy is kept by the originator and one sent to the buyer, who, when he orders, keeps his on file and sends a copy order to the originator.

It is not usual to send a copy of the requisition to the

No. 3333

PURCHASE REQUISITION

To buyer from stores No. Date:
Please order the following material to be delivered here on
Description:
Quantity:
Symbol: Bin: Specn. No.:
Normal Max.: Min.: Present stock:
Stock reserved: Balance will last:
Notes:
Signed:

FIG. 27. ANOTHER PURCHASE REQUISITION

(In duplicate: one in originating department, one to buyer)

inwards department; a copy order is sent to this department and one to inspection.

The bound book type of stock requisition in which up to twenty items may be requisitioned on one sheet should be avoided. Each item usually requires a different delivery date, and it is difficult and expensive to check up if each material has been ordered. In most cases, the items on these sheets come from stock records and are transferred from a notebook or pad—so why not write a single requisition and date-file it for checking against ordering?

Note that if single requisitions are used and are sent off smartly to the buyer instead of lying about until a sheet is filled up, the stock may be reduced by the time saved over the old method. Thus, if there is a speed-up of twenty-four hours, the stock may be reduced by one working day for each item. This is somewhat theoretical, yet in fact it works.

REQUISITION AS CHECK ON STORES

The vexed question of checking up on the accuracy of stores issues and receipts may be solved by checking up actual quantities each time a stock requisition is made out.

This technique is very simple, cutting across the unwieldy methods recommended in some books, and if operated for some time will smarten up stores method. If the method seems to be too tedious, it may be simplified by the material controller scheduling each week what requisitions will be the basis of checking; thus, all castings one week and all bar the following week, and so on.

The full check is recommended in all works engaged on general engineering batch and one- or two-off work.

SUPPLIER'S MATERIAL RECEIPT

Receipting and checking supplier's material requires only a simple system.

The design of the form used for notifying material receipt will depend on the type of organization in existence. On the other hand, it may be considered good practice to have purchasing, planning, accounts, and inspection informed when material arrives and is correct. The form shown (Fig. 28) serves this purpose.

					No.:
	MATERIAL RECEIPT				
The following material has been received from:					
Date:	Description:				
Quantity:	T.	C.	Q.	Lb.	×
Advised:	T.	C.	Q.	Lb.	×
Ordered:	T.	C.	Q.	Lb.	×
Our order No.:		For order No.:			Specn.:
Inspector's Remarks:					

FIG. 28. MATERIAL RECEIPT

When material comes in, the receiving department checks it, enters up quantity or weight, and enters this on the material receipt note; the note is sent to stores and to the material control department and checked against the advice

note and buying order. The note, of which there are four copies, is split—one for file, one for purchasing, one for inspection, and one for planning. Inspection tests the material to specification, and, if the material is correct, passes the receipt to accounts for payment of the invoice; if the material is not correct, inspection sends the receipt to purchasing, who take action. To planning and to stores, inspection sends a material release note if the material is to specification.

Yet another method is for inspection to get all receipt notes and to pass or condemn material before sending notes to purchasing, stores, accounts, and planning respectively, with suitable comments.

It will be noted that the form shown in Fig. 28 covers excess, short, and wrong material. In the case of short material, the buyer takes appropriate action and informs the receiving department, accounts, and planning; with excess material, he may accept it; with wrong or faulty material, he returns it. In each case the Material ? Note is used (Fig. 29).

No.:

Date:

MATERIAL ? NOTE

From buying dept.
Order No. has been reported
by
Remarks:
Action to be taken:

Signed:

FIG. 29. MATERIAL ? NOTE

When goods are returned, a simple return note from the dispatch department to stores, planning, buying, and accounts is used; this note gives details as to quantity or weight and method of transport.

CUSTOMER'S MATERIAL RECEIPT

A fault often found in engineering shops is that of lack of standard method covering customer's material to be worked upon (as wheel blanks) or to be used with the order (as a motor drive). The result is that material may lie in stores awaiting identification for some days.

It is essential that the drawing office inform the receiving department if and when material is to be received from a customer. This should be done on a simple standard form or on the parts list (Fig. 8, page 45), the original being sent to the receiving department and the copy kept in the drawing office. It is often a sound idea for the receiving department to send a label to the supplier, the label having the order number and the receiving company's name on it—this may save a lot of writing back and forth for the purpose of identifying material.

BALANCE-OF-STORES RECORDS

It is suggested in the chapter dealing with central production control that those records which show issues and receipts of material and the balance of material on hand be in the production office under production control, rather than in stores under, say, the buyer's control; this does not, however, affect the present issue.

There is quite a large amount of ink spilled by writers on stores organization about balance-of-stores records. While the author has found a few foundries with no such records, he has found no engineering shop that did not have balance-of-stores records in some form or other; thus little space will here be given to it.

Again, it is often recommended that this stores record be supplemented by a bin card attached to the stores bin and filled up by store-people. Many engineering companies running adequate material control without this duplication could be quoted.

A typical balance-of-stores record is shown in Fig. 30.

BALANCE OF STORES

Part: Symbol: Bin:

Max: Min: Manuf. Quan.: Price: per

RESERVATIONS

O/No.	Quan.	O/No.	Quan.	O/No.	Quan .	O/No.	Quan.	O/No.	Quan.	O/No.	Quan.

Date	O/No.	In	Bal.	Out	Date	O/No.	In	Bal.	Out

FIG. 30. BALANCE-OF-STORES RECORD

It will be noted that space is allowed on the card shown in this illustration for reserve of material. It is not sufficient merely to reserve material when an order is placed; on long-dated orders it will be necessary to file a copy of the order behind the date when the reserving should take place. Entries on the balance-of-stores record will take place from the following—

In. Material receipts (page 105); receipts of worked-upon materials from production departments, credit notes from producing departments (page 99).

Out. Parts list or material card (page 111), requisitions and drawings.

The filing of balance-of-stores records is important. If possible, they should be filed so that all of the parts for one product are together; then, by using signals, the state of balance of the product parts can easily be seen. For showing quantities reserved another signal of a different colour can be used.

The balance-of-stores record is the originating point for the requisition on the buyer when the minimum quantity is reached on a stock article (see Fig. 27, page 104). For a visible card cabinet the form shown (Fig. 30) would have part name, symbol, and bin number on the bottom, and in most cases would have printed figures for date, follow-up, and noting material movements.

DIRECT MATERIAL RELEASE FOR FABRICATION

A point seldom distinguished by writers on material control is that the necessary mechanism for release of material for assembly departments differs from that of other departments. Thus, the release of a motor shaft for fitting is quite a different matter from the release of bar material for the machine shop to make a number of motor shafts.

For release of material for a machine shop the part drawing plus a material release note is best, while for a fitting or assembly shop a parts list or material card is best.

In some shops the part drawing has a columned space on the right-hand side for statement of order number, number off, material, quantity, and date of order. The part drawing goes to stores—stores check quantities and reserve material against its being moved. When the job is finished the drawing goes back to drawing stores with the columned data scored through; when a similar part is needed, the same drawing comes out with the data in the next column.

The foregoing method would be an improvement on the method of many engineering works, but the idea of using a part drawing for material quantities and the like is not the

best; in any case, it may leave stores without a record proving issue of material. Thus, while a special move ticket authorizing the movement of material into shops and kept in stores as a record is a sound idea, it is better to have a material release note (Fig. 31), for, it is to be noted, material is not usually moved into the shop when it is got ready (if it were, it would cause confusion); usually it waits until a move ticket (Fig. 32) is passed to stores.

MATERIAL RELEASE	
To Stores	Please get
material ready for Job	
Drg.:	Quantity:
Dept.:	Section:
Date Ready:	
Sig.:	

FIG. 31. MATERIAL RELEASE NOTE

MOVE TICKET	
To:	Please move
material for Job	
Drg.:	Quantity:
From:	To:
Date Moved:	
Sig.:	

FIG. 32 MOVE TICKET

The full use of both material release and move notes is discussed in Chapter XX.

DIRECT MATERIAL RELEASE FOR ASSEMBLY

Further confusion among writers on material control arises from failure to understand the different techniques required for the simultaneous issue of completed parts sufficient to assemble a whole product and the gradual issue of needed parts for, say, a product requiring eight or nine weeks for assembly.

In those shops where it is the practice to issue at one time a set of sub-assemblies and single parts to be assembled into a complete product, it is sufficient to use a move ticket authorizing the withdrawal of x units from the already issued stock order. However, in those shops where assembly departments require material from day to day, the parts list or a material card will be the basis of material release.

Especially is it stressed that the material card—

(*a*) List *all* parts (not leave out bolts, nuts, washers, and the like).

(*b*) List parts so that sub-assembled parts are together.

(*c*) Give material quantities (not leave the fitting shop foreman to calculate copper piping for the oil system or the plating foreman to develop shapes by rule of thumb).

MATERIAL CARD

Written by:
Checked:
Issued:

Arrg't. Drawing: No. of Cards: Card No.:
Order No.: Description:
Test Detail:
Client's Parts:
Delivery Detail:
Stamp Nameplate:
Special Detail:

Part No.	From Stock	Description	Drg.	No. Off	Matl.	Quan.	Wt. lb.	Cost

FIG. 33. MATERIAL CARD

It will be noted that the material card shown allows for material costing by the material control department; this may or may not be feasible in particular shops.

In a shop where special machines are built, the simplest

technique is to give both stores and the fitting shop a copy of the material card (or of the parts list). When material is required, the fitting shop runner brings the card which is marked off when he receives material, and at the same time the stores copy is marked off. If the material is from stock, the entry is later transferred to the balance-of-stores record (Fig. 30).

Note that standard parts lists are used for all stock products, but when a standard product has some special substituted or extra part in it, it is usually worth while issuing a special parts list with all standard and special detail—there is perhaps as much grief in general engineering shops because of failure to fit pulley so-and-so, or use special grease this or that, and the like, as from any other cause. And all because of desire to save a few coppers on the parts list issue. Elsewhere (Chapter VII) we deal with parts lists from the drawing office standpoint, and the methods to be used for altering lists of parts and allowing for scrap and similar matters.

In passing, the issue of material to replace items scrapped or "lost in shop" should take place only on receipt of a release note from the planning department (or the drawing office if there is no planning department); this note will originate from the inspector's report on the operation or operations concerned (see Chapter X).

WHO SHALL REQUISITION STORES?

It is not often clearly recognized that the only cases in which stores should be requisitioned for material are when indirect material is required—all other materials should be issued against parts list or material cards, drawings, and replacement notes from the drawing office and/or planning department.

Stores will be requisitioned only for stock indirect material; and it is worth while, as is mentioned earlier in this

chapter, to list all of these stock items and to state explicitly who shall requisition and what shall be requisitioned. Here is a typical list—

Turning Foreman. Chalk, paraffin, tallow, waste, cutting compound, lubricating oil, and (see Chapter XVI) replacement of brooms and broom handles, drill sockets and drifts, buckets, spanners, oil cans, hammers, and tools on production and damaged or worn articles.

Foreman Electrician. Adaptors, fuse wire, copper bar and strip, electric cable, bends, conduit, fuse and junction boxes, electric lamps, hand lamps, switches, and the like.

No.:

INDIRECT MATERIAL REQUISITION

To stores. Date:

Please supply following new (replace) material

for use by Dept. on

Signed:

Order or a/c No.: Issued by: Recorded by:

FIG. 34. INDIRECT MATERIAL REQUISITION

The requisition shown in Fig. 34 is a generally useful form, but if necessary a special form may be issued for various departments. Where accounting is on the punch-card system (see page 116), a punch card may be used. It should be noted that for all replace and new works and office equipment a special form should be used.

CONTROL OF INDIRECT MATERIAL USE

The control of direct material use finally materializes as job or process material costs relations to known figures. The control of indirect material is not, however, so easy. It is usual to show the cost of machine and building replace materials as a figure in the monthly profit and loss account; other indirect materials, excepting tools, are grouped in one

figure. These various figures may be compared with previous figures or with a budgeted figure; but, as is the weakness with all financial controls, the budget is derived from experience and not from analysis, and in any case the loss shows up only when it has occurred.

It is suggested that, in the large company at least (employing 1000 people upwards), control extending to departmental use of indirect materials be set up and used, and that where possible direct observation plus departmental records be used.

In the case of lamps, buckets, barrows, brushes, hammers, files, chisels, and tools (dealt with under Tool Control), it may be sufficient for practical purposes to ask for an old item before a new one is issued; but this is not enough. The cost department should summate all indirect material costs and quantities by departments, and, until such times as direct analysis can be made, supply the stores department with a budget of departmental quantities. Stores would then record items as issued against departments on an indirect material analysis sheet. This technique is not worth applying to material such as waste, but it certainly is to more valuable material, and this extends from pencils and rubbers to buckets and barrows (tools we are not meantime considering): it will be found illuminating even if used only for a time.

On the other hand, if machine lubrication and repairs and replacement of barrows, buckets, brooms, and the like be in the hands of the maintenance department, and lamps and electrical supplies be in the hands of the electrical department, and these departments must both requisition their particular materials and be responsible for their use, much good will be done. But, whatever the method, records should be departmental, and, in the case of tools and machine repairs, be listed under the machine or the operator of the machine.

MATERIAL SALVAGE

For our purpose, material salvage may be divided into the following categories—

(*a*) Salvage for sale.

(*b*) Salvage for use.

The latter has received much more attention than the former in literature, especially the salvage of strip and sheet metal remainders; this, however, is too obvious for treatment here.

Under salvage for sale, the most important items generally are the swarf and turnings from bronze, aluminium, copper, brass, alloy steels and mild steels, and the unworkable ends and cut-off pieces of cast and other irons.

It is a good practice for the material controller to standardize what lengths and diameters of used bars and areas of used sheet should be returned to stores, and to standardize what amount should regularly be kept in the stores. One shop, for example, found that roughly 33 per cent of all pieces of bar from 1 in. diameter upwards measuring between 5 in. and 8 in. could be used. Previous to this, pieces of these lengths were scrapped.

It is usual to use magnetic separators for swarf separation, but in fact what is usually most required is control at the point where swarf mixing takes place. It will be found a good plan to issue a cleaning note to a machine cleaner every time the desk or progress clerk observes a change-over from one material to another, and cleaning is standard to such a change-over. This ensures cleaning immediately the machine operator clocks off one job and on to another.

When it is considered that one large company lost about £800 each year through swarf mixing, the value of such a measure as is mentioned above will be appreciated.

COSTS OF MATERIAL CONTROL

The costs of material control in an engineering shop will vary with the kind and number of products. Excluding issue and receipt of material, and stores labouring (see under Stores Costs in Chapter XIV), the costs of transferring data from release notes, parts lists, material cards, and replacement notes to balance-of-stores cards, of checking certain stores each time the buyer is requisitioned for these stores, of requisitioning on purchasing, and generally of keeping an eye on material use, are as follows—

1. Shop employing 200 people on hoisting equipment of a fairly general and partly special nature: one clerk who assists planner about one-quarter of his time, the remainder being on material control.
2. Shop employing about 250 people on electric motors, 35 per cent of motors being partly special: one clerk.
3. Shop employing 1800 people on special, small, and large batch general engineering products: two male and three female clerks.
4. Shop employing about 150 people on standard and special pumps of various types: one clerk.

PUNCHED CARD CONTROL COST

In recent years there has been a development of the use of punch cards for stock control in companies making only one type and size of product. As each item is issued, a card is abstracted from a box. Each day, all the cards are passed through tabulating machines, and the decrease or increase of stock value and quantity by lines, and as a whole, is shown mechanically. In other shops the ordinary balance-of-stores record is kept; but data from material cards (page 42) and requisitions are transferred to a punch card for accounting by, it may be, jobs, stock lines, and departments. These methods do not so much save labour cost as increase

speed and accuracy of control where the materials are applicable.

MATERIAL CONTROL AND OPERATION DATE PLANNING

In those works carrying finished parts for assembly into the product, the balance-of-stores record (Fig. 30, page 108) should have on it maximum and minimum quantities to be kept in stock. Given that when the minimum has been reached a further quantity is ordered, when, it may be asked, is this quantity required? The days allowed for getting in from outside suppliers or receiving from the shops the quantity ordered should be less than the time the minimum quantity will last. This time is put on the balance-of-stores record and is transferred to the requisition for material—thus giving a basis for operation date planning of stock parts.

CHAPTER XIII

THE LABORATORY AS A FACTOR IN MATERIAL CONTROL

THE laboratory aspect of material control is almost universally ignored by experts when, in fact, in terms of customer service and, too, of money-saving to the company, it is often of more fundamental importance than the more greatly verbalized binning and issuing systems.

In these days of specifications for castings, stampings, forgings, rolled bars, and metals generally it is essential for the buyer of metals for use in a product to have laboratory controls of some kind—whether or not he sets up his own, or uses the services of one of the excellent laboratories usually to be found in most industrial towns.

ESSENTIAL CONTROLS

In general, for control of quality of material, the following may be said to be necessities—

1. A method of procuring certificates of analysis from suppliers; when suppliers are reputable, this works quite well.
2. A method for test of soundness of steel bars, billets, and stampings—hot acid equipment.
3. Hardness testing—brinell hardness tester.
4. Tensile and impact testing—small or large tensile testing machine and Izod impact machine.
5. Carbon, silicon, sulphur, phosphorus, manganese, nickel, and chromium estimation tests—general laboratory equipment.

There is not alone control of inward material to be considered; there is control of materials processed through, say, casehardening and heat treatment, and also there is the testing of parts broken in process or in service, plus the

thousand and one services a laboratory can confer on the executive official who uses it intelligently. Such equipment as is outlined will cover most needs.

EQUIPMENT OF A SMALL LABORATORY

Here we are not concerned with the large company employing 500 or more people, but with the company having about 150–300 people which has not yet set up laboratory control of material—the larger company should have such controls.

For hot acid tests of steel bars, billets, and stampings, the chief requirement is a chamber for fume discharge; a silica basin and a supply of commercial hydrochloric and sulphuric acids are further necessities. Boiling of the piece under test in the basin containing the mixture (1000 c.c. hot water, 400 c.c. sulphuric acid, 1250 c.c. hydrochloric acid) for about thirty minutes exposes a smooth sawn or turned surface of the sample for examination.

With the brinell hardness-testing machine most useful tests will be carried out. Incoming material can be checked for correctness of normalizing or heat-treatment operations, and process testing of shop-treated products and tools can continually be carried out.

For the checking of material ultimate strength and ductility a tensile-testing machine is necessary. If a large machine is too expensive, the purchase of a small tester will be an economical investment and will give accurate results. Similarly, a small impact machine may be used for resistance of material to shock tests.

For the chemical tests mentioned in the previous section of this chapter the following are required—

Muffle furnace 4 in. × 3 in. × 8 in.

Carbon-estimation furnace.

Gas or electric hotplate.

Fume chamber.

Sensitive balance (aperiodic prismatic reflecting type, for choice).

Rough balance—2000 grammes.

12 fireclay crucibles.

1 Bunsen burner.

Reagent bottles (24), conical beakers (48), boiling tubes (24), 3 in. funnels (24), forceps, crucible tongs, spatulas, necessary chemicals, filter papers, and other details.

Perhaps the best way to equip a laboratory is to get hold of a young chemist or a metallurgist, budget to him the cash to be spent, and ask him to make a good job of the spending.

The testing of material inwards and of standard process work should be on a planned basis as to method, periodicity, and quantities to be tested (see Chapter VIII, page 59).

LABORATORY COSTS

Despite the easy claims of those people who write about industry as if every business is a mass-production business, neither the chemist nor the metallurgist is generally appreciated in industry. In many companies "he and his theories" are looked upon as liabilities, and if there is a badly lighted and ill-ventilated room in the building, he will be working in it, and his departments—heat-treatment, metal melting, plating, and the like—will be equally ill-equipped.

The majority of executive engineers and metal founders are not yet "science-conscious" to the extent that they are "stop-watch, planning-board, and budget conscious" (thanks, paradoxically, to "scientific management"). Yet the cost of equipping and running a real material control department and laboratory is not excessive.

The equipment for hot etching and for brinell, tensile, and impact testing machines will cost about £120 if the machines are of the small type. To equip the laboratory for carbon, silicon, sulphur, phosphorus, manganese, nickel, and

chrome testing will cost about £120, or less if a determined effort is made to do the job more cheaply.

From the operating cost standpoint, the small engineering shop with a foundry can keep a metallurgist and a young assistant busy. In engineering shops employing fewer than about 250 people, it may be feasible to incorporate inwards material dimensional inspection with testing and analyses. In a shop of this size, however, if a metallurgist is given a fair chance, he will quickly pay his way and to spare. Yet another scheme is to incorporate research with laboratory operation; but, whatever the scheme, every engineering shop aiming to produce a decent product needs such controls as are outlined here.

CHAPTER XIV

STORES

It is not unusual to find authorities on business organization confusing the functions of material control and of storing material. Thus, Diemer says,[1] "Custody and accounting are the real functions of the Stores Department." Moreover, it is no less unusual to find the same authorities illustrating bin tickets of various sorts which have to be filled in by the people who receive and issue material.

The reasonable tendency in engineering companies ranging in number of employees from 100 to 5000 is to separate the function of giving out and taking in material from the material-recording function. Stores, then, to us means the place or places where material is received from the receiving department and issued to the various direct and indirect departments; stores may also receive partly-finished and finished work from production departments.

INVESTIGATING STORES ORGANIZATION

When called upon to investigate stores organization in relationship to the whole business, our attack would probably be as follows—

1. Consider tonnage material handled per period; largest pieces, greatest weights, boxes and barrels received.
2. Stores location in relationship to receiving points and points where material is used.
3. Handling of material into stores from outside suppliers.
4. Stores internal lay-out.
5. Stores racking, binning, and stacking of material.
6. Stores internal handling.
7. Stores issue points.

[1] *Factory Organization and Administration* (McGraw-Hill).

8. Stores design for prevention of loss of material.
9. Stores labour costs.

In the average small general engineering company (employing about 150–200 people) and in the company making products assembled from light parts, with maximum weights of the heaviest part about 50 lb., the problem is not likely to be so complex as in the company of larger proportions using quantities of heavy material.

STORES LOCATION

After having direct experience of numerous engineering companies of various sizes engaged on various products, the writer does not care to repeat management textbook maxims on stores lay-out. On the other hand, certain general principles arise which are worthy of consideration; it appears that the location of stores will, in general, depend on—

(*a*) the number of floors in the operating section of the business;

(*b*) the different kinds of products made;

(*c*) the width and length and varying levels of the building;

(*d*) the distance the product parts flow;

(*e*) the weights of particular parts;

(*f*) the state of balance of works productive capacity; and

(*g*) the weight of sub-assemblies and the location of sub-assembling points to raw material stores and to assembling or fitting shops.

Given one had plenty of land and the cash to build ideal business premises, as textbooks take for granted, the problem would be quite different—as it would be if every engineering works were on mass production. The following examples will illustrate this point.

A SMALL ENGINEERING SHOP

A pretty problem was presented quite recently to the writer. An engineering shop employing 135 people had a tool stores and a general stores with a man in each, but had

five other store places scattered about the shops. The following were the facts which materialized as shown at (A) in Fig. 35.—

1. The company could not afford a change round of plant.
2. Electrical testing equipment was too costly to move.
3. Some very heavy bars (6–14 in. in diameter) and castings (3–15 cwt.) were used.
4. There was very little control of stores, and of scrap replacements especially.
5. The existing storekeepers' labour was not fully utilized.

The compromise shown at (B) in Fig. 35 resulted, and the new planner (the machine-shop foreman trained and promoted) was placed in charge of stores.

The lay-out shown is contrary to many textbook rules, for heavy bar and heavy castings are not under a store-keeper's eye; nevertheless, if limitations of space and of money be considered, the lay-out is economical and workable.

Many small engineering shops have very little centralized storage of material, and unfortunately many managers of these shops think it not worth while. It is agreed that it is not worth while handling machined heavy parts back into the stores; but, in general, *it is better to have good control of material—and this presupposes storage against pilfering and loss—than to aim at minimum handling and not have proper storage.*

In the foregoing example, a further aim was to centralize the newly-fostered planning and ratefixing with stores—all material records are now kept in the planning office. The next step is to move the electrical shop to where the tool stores originally were, and thus to take direct control of timber (to go where heavy bar and castings are) and of heavy bars and castings (to move up to the electrical shop). This will leave heavy finished parts out of stores direct control, but, until turnover is greater, these parts will be left as at present.

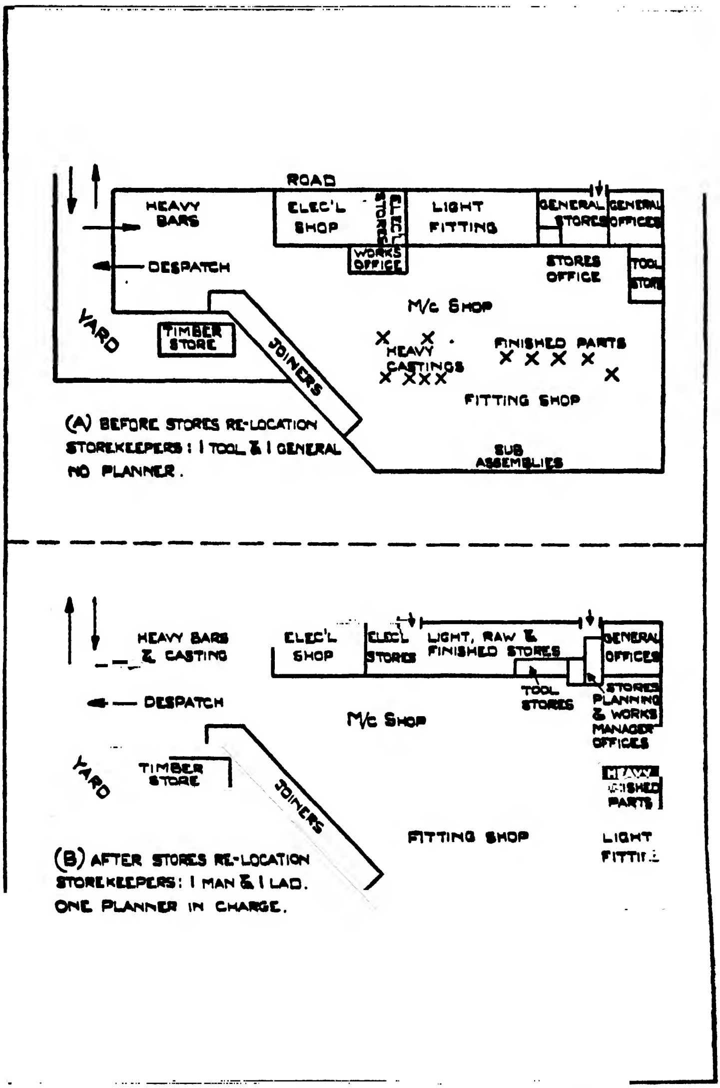


FIG. 35. SMALL STORES BEFORE AND AFTER REORGANIZATION

A LARGE ENGINEERING SHOP

This example is of a fairly large company employing about 2000 people. The facts which led to the stores alterations (see Fig. 36) were as follows—

1. Average internal trucking distance was one-eighth of a mile.
2. Longest trucking distance was close on a quarter of a mile.
3. Only one crane served the stores.
4. Congestion at stores entry from outside.
5. Heavy material had often to be transferred from stores cranes to other cranes in two of the shops.
6. Labour in finished parts stores not properly utilized.
7. Shortages at year end in finished parts stores totalled over £1400.

The new lay-out gave the stores the use of three cranes, centralized the finished parts stores and the tool stores, and cut down internal transport and stores costs. Moreover, it cut out much of the loose control.

It is noteworthy that many large engineering companies seem to favour the use of many rather than few stores. There is a tendency to consider only superficial handling cost, and to dot stores here and there to reduce this cost. Diemer advises that "*storerooms should be located so that they serve the floors or areas involved with a minimum amount of travel,*"[1] and it is not surprising that this fairly general sort of advice is widely followed; to the advice the following should be added: *If, in so doing, stores labour utilization costs do not become overhigh, stores can properly be guarded, and control is not lessened by decentralization.*

STORES INWARD HANDLING

It is worth observing the effectiveness of handling of stores at the entry ramp or staging: experience shows that

[1] *Factory Organization and Administration* (McGraw-Hill).

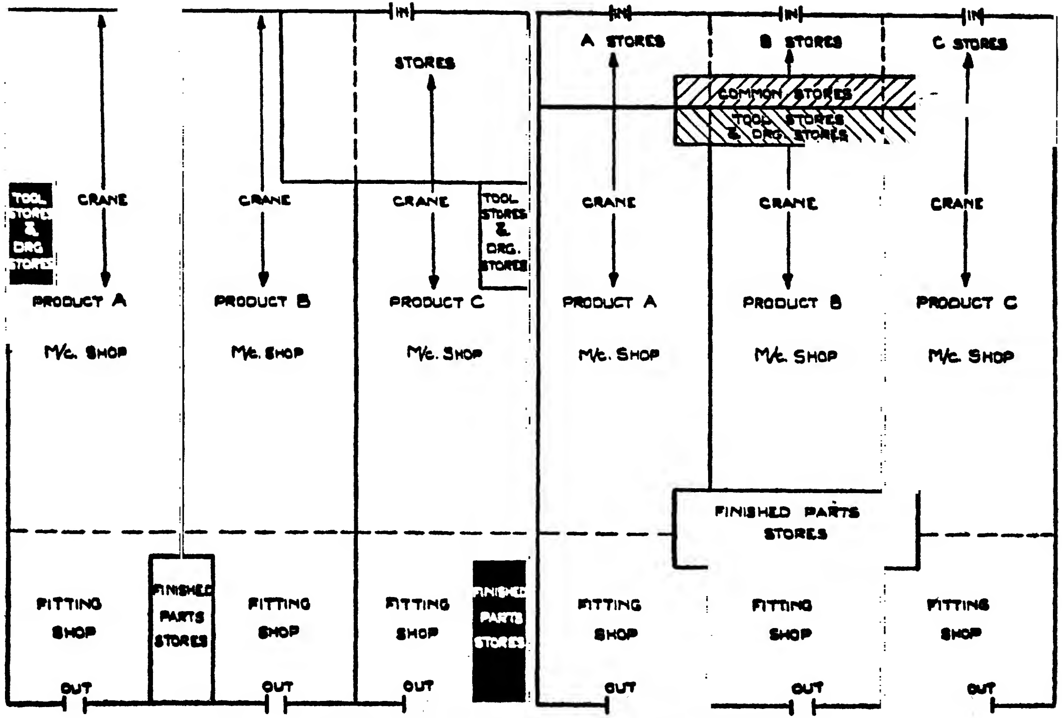


FIG. 36. LARGE STORES BEFORE AND AFTER REORGANIZATION

in many instances costs are high. The following result of a study of the movements at the stores entry of a well-known company will illustrate the point.

Thursday, 11th August, 1938

2.00 p.m. . .	5-ton wagon waiting—wagon loading lower down. (Cause: bad lay-out.)
2.45 p.m. . .	5-ton wagon in stores—15 lifts for 5 tons of blanks.
3.00 p.m. . .	5-ton wagon off. Petrol truck waiting. (Cause: single entry.)
3.05 p.m. . .	Railway mechanical horse in.
3.10 p.m. . .	,, ,, ,, in.
3.35 p.m. . .	,, ,, ,, out. Petrol truck in, but blocked by material on floor. Crane loads truck.
3.37 p.m. . .	Railway wagon in.
3.55 p.m. . .	Railway wagon out.
3.57 p.m. . .	4-ton wagon in.
4.37 p.m. . .	4-ton wagon out.
4.39 p.m. . .	Petrol truck now out.
4.45 p.m. . .	5-ton wagon in. 2-ton wagon waiting.
4.55 p.m. . .	Petrol truck waiting to get in.
5.00 p.m. . .	Man leaves petrol truck and goes home.

It was reckoned that delays at stores entry cost close on £2 10s. per day; this apart from shops having to wait for material owing to internal blockages.

There is little doubt that a man with a stop-watch and a pad would be a good investment for one day at many works and stores entrances.

MATERIAL BINNING AND STOCKING

Here we are not concerned with accurate recording of quantities of pieces of material binned, but with the general aspects of the subject.

In many works, the space occupied by stores appears to be inadequate, and often is; but it is surprising what can be done to save space by effective storage method.

In a stores, *utilization of air space* means better utilization of floor space. Thus, a barrel or a bin 3 ft. in height, having perhaps 20 ft. of air between its top and the roof, is poor

floor-space utilization. If bins and barrels (the latter on their sides) are kept on shelving, two or three tiers may be used.

Again, in many stores one finds castings and stampings weighing under 50 lb. on the floor. Articles such as these can be binned in racks, or, if the articles have holes, they can be threaded on three-feet-high rods mounted on flat bases.

A handy method of stacking castings and stampings is in portable bins. These bins are loaded with a definite quantity of articles and are stacked into each other. When a number of the articles are required, the bin may be slung directly into the works or a quantity may be abstracted from the bin. Fig. 37 illustrates this method.

Racks should be of metal rather than wood, and they should, in works of a changing type of production, be designed for standard interchangeable shelving or for fillers. Quite recently, in a moderate-size works, standard wood racks were made and built up on the expanding book-case principle; Fig. 38 illustrates the flexibility of this type of rack.

INTERNAL HANDLING

If stores can be so laid out that the cranes which run over the main shops serve it, handling will be fairly economical (see Fig. 36). On the other hand, cranes running at right angles to the length of the stores do serve economically to move heavy material from one end of the stores to another. An attempt should be made in unloading to unload opposite the bay to be served, or at least to unload on to trucks which can be unloaded where the material will easily be handled into the shops.

One often finds that the location of racks and bins is such that a considerable distance has to be covered from

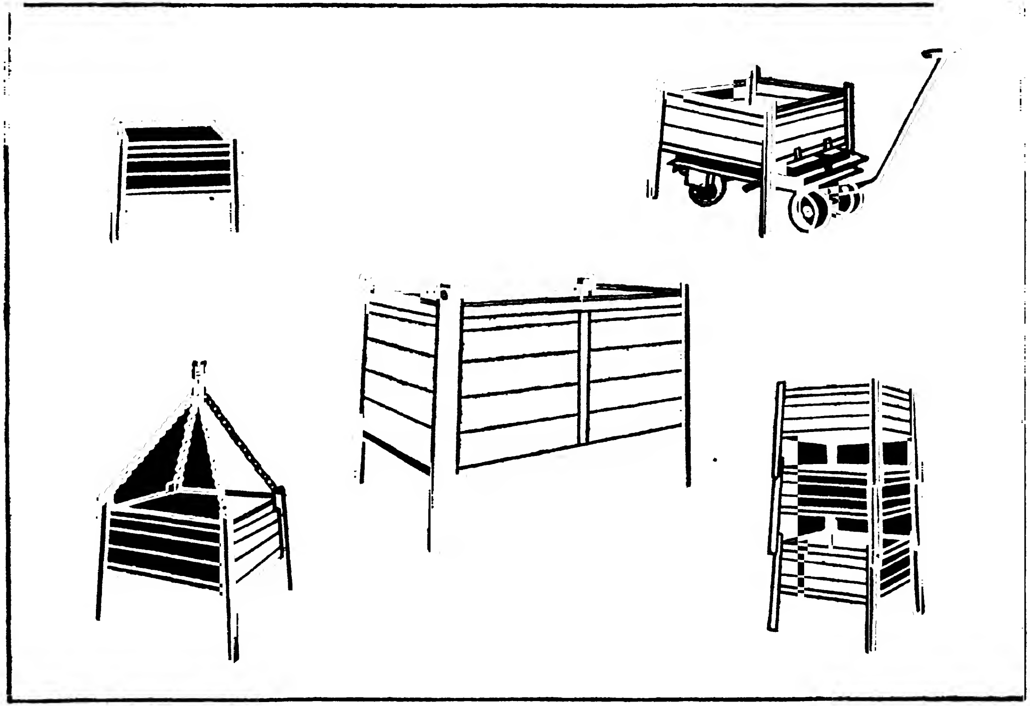


Fig. 37. Combined Trucking and Racking Bins

the point of material issue. A recent study showed the following—

	min.
Walk to issue window (40 times)	20
Walk to material	17
Get material	28
Walk to issue window	21
Back to records desk	17
Total time . . .	103

This particular window served a fitting shop with fitting details, and study showed that in nearly 60 per cent of cases bolts and nuts were issued; these were brought nearer to the issue point and showed a calculated saving in time of 33 per cent on issue.

It is very illuminating to study the numbers and types of issues from stores issue points in a defined period, to note to whom the issue is made and to where it goes, and to graph or table the results against a stores floor plan. It is seldom that substantial savings do not result.

STORES LABOUR COSTS

Of recent years there has been a spate of treatises on "How I Put the Stores on Bonus" and the like. It is noticeable, however, that when the formulae for bonus calculation are examined, many of the major variables are missing. Too often a calculation of the weight handled is the base, with consequent loss of accuracy in the calculation; sometimes number of issues is the base, and, less often, a combination of issues and of weight.

The dispatch department one can put on bonus fairly easily, because assembled units usually form a reasonable basis for calculation; but with the variety of pieces handled in a stores where products vary in kind and in size it is not easy. In any case, the stores-operating staff cannot normally determine its own input and output—the production departments determine these.

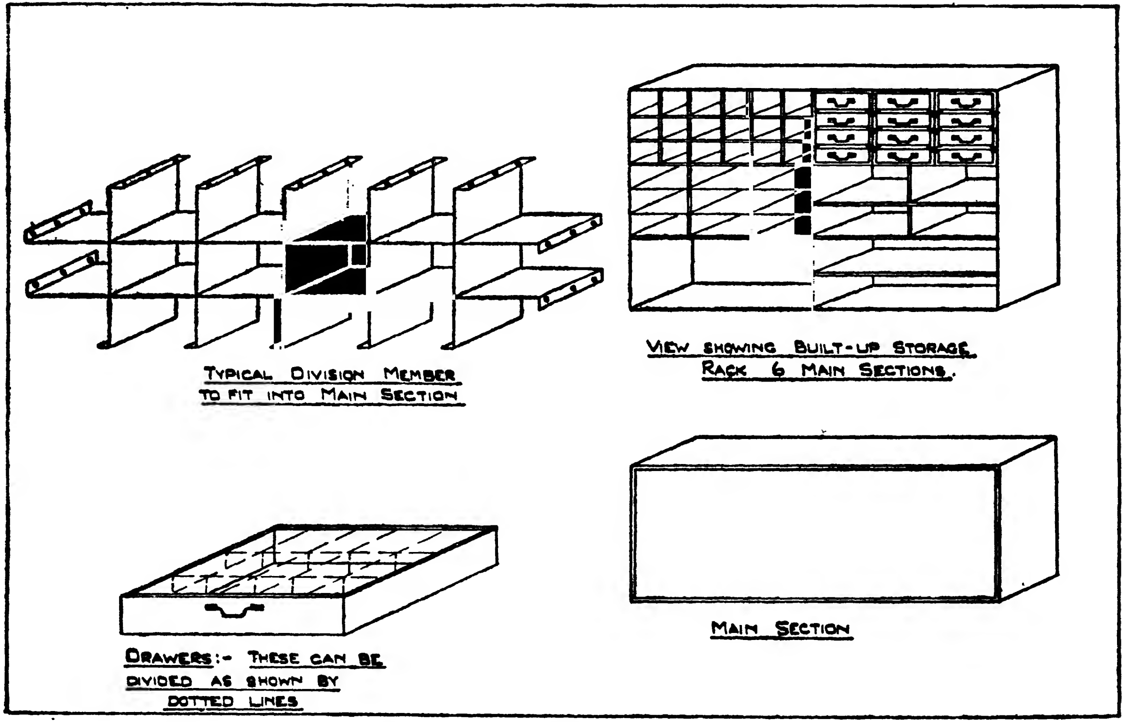


FIG. 38. UNIT RACK STORAGE SYSTEM

Where, however, material is sawn, cropped, or drilled before issue to shop, the operators of these processes may be on some kind of bonus. On saws, however, if the labour cycle to total sawing cycle (floor-to-floor time) were studied, it would usually be found to be too low. A labour cycle of 60 per cent (see page 180) should be aimed at—on high-speed circular saws the labour cycle is, of course, higher than this.

The writer has found that bonus in a stores may be only an apology for lack of control. In one shop where stores bonus was paid it was claimed that the number of storekeepers was reduced from seven to five. In actual fact, the five were not operating at bonus speed, and they, in any case, represented the normal stores labour to total other labour ratio for the works—one storekeeper per 100 workers where more than 200 workers are employed. Below 200 the ratio for general small and medium batch engineering may be two per 100 workers.

If we put the stores labour to direct labour ratio as a money figure, the following are typical; machinemen employed in stores are not included, nor are clerks or order checkers; cranemen, slingers, and material issue and receipt men are—

Type of Shop	Per Cent Stores Labour Wages to Direct Labour Wages
1. Small batch and jobbing with 3 products—140 men	1·3
2. Small batch and few singles—780 men . .	1·15
3. Small batch and jobbing, 4 products—1500 men	1·05

A control ratio such as the foregoing is as good as any other for stores labour cost control. If anything further is

desired, number of issues and weights will require calculation. To these it is strongly recommended that such factors as percentage wrong to correct issues, stores cleanliness, and non-mixing of parts in bins be added.

But why not a decent day rate as an incentive? A rate of 12½ per cent more than labourer's rate for issue and receipt men is by no means too much. To the honest labouring type promoted to storesman a flat incentive of this type is best. If a man be solely in charge of stores, as in a small works, a higher flat incentive would be paid.

People who are keen on bonus for stores labour should remember that honesty and dependability are major requirements for this type of work; bonus, as is often the case in production departments, may foster "wangling."

CHAPTER XV

PLANNED MAINTENANCE

THE savings arising from planned maintenance of plant and equipment can be very considerable, and as the technique is not difficult, it can be applied with profit to at least the operating plant of all engineering companies.

MAINTENANCE EFFECTIVENESS ANALYSIS

Analysis of maintenance effectiveness may take place from the following standpoints—

1. Cost of maintenance for each item in terms of depreciation and/or first cost.

2. Production cost in terms of break-downs, slowing of output, and production of poor work.

3. Engineering analysis.

One can certainly go through the cost of maintaining each item of plant and machinery, and by induction conclude whether or not the machine is worth keeping. But the cost of maintenance may rise with poor maintenance or with careless operation; thus any conclusion come to will require an engineering analysis. So with production cost analysis—it also may lead to false conclusions without engineering analysis.

For analysis of production machinery it will first be necessary to know how accurate each machine should be, then, in terms of this, to examine each machine instrumentally and visually.

To procure information on how accurately the machine was built, it will be necessary to write to the makers of the machine. Some machine builders do not care to quote machine tolerances; if the machine in question be less than

three years old and the maker will not quote its original tolerances, Schlesinger's tables should be used.

In passing, new machines should be bought to specifications as to accuracy, and should be checked up instrumentally before being put into use and one month afterwards.

But, apart from using makers' or Schlesinger limits as a base, the analysis should be made in a logical fashion. The items to be analysed should be laid out on paper, and the order of tackling each decided upon. The author has found it useful to get out an analysis sheet covering machine accuracy and speed for each machine department and to get the opinions of each foreman on the machines under his care. This will gain the foremen's co-operation and serve as a base for the analysis.

TYPICAL ANALYSIS RESULTS

Two results of such an analysis are given hereunder—

	Total Machines	Machines Good	Machines Scrapped	Bad Condition	Fair Condition
Case 1 . .	603	332	63	81	127
Case 2 . .	117	63	11	15	28

Subsequent instrumental analysis generally bore out the foremen's opinion and made their needs factual.

That is the point about maintenance engineered analysis: it makes clear in figures that will not be denied what the financial and other chief executives get only as general opinions. Thus, to say "This capstan machine is 0·020 in. out on the bed, 0·015 in. out on the work spindle, and 0·010 in. out in each tool hole and will cost £x to repair" is much more potent than to say "This machine is no good, and we want a new one." Moreover, it puts maintenance on a factual basis.

Buildings, electric, water, oil, and air connexions, handling

plant, and other items not classed as production equipment should also be classified and examined with a view to setting up planned maintenance.

PLANNED MACHINE MAINTENANCE

Planned machine maintenance is not, as is often suggested, a matter of running over the whole machine with instruments once per so often. Economical practice suggests that although the axis of the centres in a lathe be tested, say, once per quarter the cross-slide need not so often be tested; similarly with the axis of the spindle and the lead screw and nut.

A card (Fig. 39) should be designed to cover the various inspection points on each machine, and for each of these points a tolerance should be stated. In setting the tolerance the finest tolerance required on the work produced on the machine should be kept in mind.

This illustration shows the necessary tests on a centre lathe. On the other side of the card are entered details of any necessary repairs. One company uses this side for machine idle-time recording as well as for repair costs.

It will be noted that the card is figured on top to cover twelve months. This is useful in conjunction with colour signals for reminding the machine inspector when the machine comes up for inspection.

The person chosen to carry out machine inspection should rather be part of the product inspection staff than part of the maintenance staff. When a machine is repaired by the maintenance staff it should be inspected before passing to production.

PLANNED GENERAL MAINTENANCE

The following tabulation suggests a workable routine for planned general maintenance—

1. Finished jobs done by maintenance department; inspect when finished.

INSPECTION DETAILS

Inspect the Following Parts	Normal Tolerance	Condition	Inspection Period	1	2	3	4	5	6	7	8	9	10	11	12	13
Axis of spindle . .	0·002 in. error	0·002 in.	quarterly	·002			·002									
Axis of centres . .	0·001 in. error	0·001 in.	,,	·001			·001									
Alignment of headstock .	0·002 in. ,, in 6 in.	0·012 in.	,,	·012			·002									
Alignment of tailstock .	0·002 in. ,, in 6 in.	0·002 in.	,,	·002			·002									
Cross-slide test . .	0·001 in. ,, in 5 in.	0·002 in.	,,	·001			·002									
Lead screw . . .			half-yearly													
Lead nut . . .			,,													

FIG. 39 INSPECTION CARD

2. Daily inspection; safety guards, fire escapes, water, gas, steam, and like equipment.

3. Weekly inspection; electric wiring, ventilating and heating system; casehardening and other furnaces.

4. Fortnightly inspection: roofs and lifting mechanisms and accessories; switches and switchboards; pressure vessels.

5. Monthly inspection; stores and inspection wire guards and doors; power trucks; line shafting.

6. Quarterly inspection; floors, yards, dividing fences and walls; building generally; electric motors.

7. Half-yearly inspection; all painting, and plant and building finishes.

It is worth while getting out a complete card index for each item to be inspected, and the card should be laid out so that the inspector is guided in his task and can make entries against each inspection factor.

Motor lubrication and cleaning should be carried out periodically, depending on types and designs. Lighting, both natural and artificial, should be the subject of weekly inspection. The cleaning of windows and light reflectors will vary in period of application from one department to another (as a forge shop and a machine-shop); the rule is—keep them clean.

MAINTENANCE ORGANIZATION

Maintenance, in the small works, is usually responsible to the works manager, who is also the production manager. In the larger works, of 500 people or more, maintenance may be responsible to the production engineer, or if production engineering is responsible to the chief engineer, to the chief engineer direct.

It is essential in all but small works that maintenance department work be loaded and scheduled; that is, all but small jobs of less than, say, 2 man-hours should be listed,

estimated as to time, and scheduled in order of necessity. A total hours load on the department can then be run out for mechanical, electrical, and civil work respectively. It is usual for the maintenance chief to budget the costs of all jobs likely to take more than 2 man-hours and to turn in the budget to the cost department before starting the job.

The procedure for requisitioning the maintenance department should be standard (see page 59), as should the procedure for requisitioning material for maintenance purposes (see page 112). Costs should code up maintenance expense as X.M.B.R. (see page 28)—"Expense, Maintenance of Building Roof"—and maintenance orders should bear the apposite code numbers.

MAINTENANCE COSTS

The following figures are not based, as is usual, on the ratio of maintenance wages to total direct wages, but show maintenance hours to total machine hours and to total direct hours for the works. The maintenance hours include supervision hours but do not include time spent on erecting new structures—

	Maintenance Hours	Machine Hours	Total Direct Hours
Case 1	2700	251,000	482,000
Case 2	2950	347,000	705,000
Case 3	3870	468,000	692,000
Case 4	7900	976,000	1,698,000

Note that machine lubrication and belt repairing are included in the foregoing figures.

CHAPTER XVI

TOOL AND GAUGE MAINTENANCE AND CONTROL

THERE is a great diversity of practice among engineering works in tool, gauge, and jig and fixture maintenance and control. Looking back on his contacts with engineering companies, ranging in size from 50 to about 2000 people employed, the writer can quote large companies which allowed machine operators to hand-grind taps and drills, and which had little or no jig inspection, just as he can quote small companies whose practice was quite contrary to this.

Yet there are certain fundamental good practices worth considering for almost all engineering works.

EFFECTIVENESS ANALYSIS

Any analysis of the effectiveness of tool stores and tool maintenance procedure will fall naturally into the categories of—

1. Location of stores in terms of department service.
2. Lay-out of stores and of tool maintenance.
3. Gauge, tool, machine part (as collets), and jig storage location and method.
4. Tool classification.
5. Tool specifications: materials, design, and tests. Authority to grind tools.
6. Economic factors (expense against savings) considered in tool-making and purchase.
7. Tool inspection procedure and method.
8. Equipment of tool-maintenance department (or tool-room) with special reference to accurate work and capacity to carry shop peak loads.

9. Work loading and scheduling in tool-maintenance department (or tool-room).

10. Tool requisitioning on buyer: authority for, forms used, flow of forms.

11. New tool requisitioning on stores—as (6) above.

12. Tool issue and return procedure.

13. Tool control records as to tools in stores stock, issued tools, tools damaged, scrapped, and lost, tools at machines and benches as permanent base stock.

14. Speed and accuracy of tool issue and receipt.

15. Tool salvage: as plating gauges or grinding down gauges, tool tipping, recutting files.

16. Cost ratios for control.

LOCATION, LAY-OUT, AND RACKING

We do not here intend to become discursive on tool stores location, lay-out, and racking; these are written about so often and so much under the guise of small-tool organization and are so repetitive that we can afford largely to ignore them. After all, the principles governing these factors are true of all stores, and as they have been covered in Chapter XIV, the reader is referred to that chapter.

One aspect of this problem worthy of practical notice is that of heavy jig storage. There is a great deal to be said for the keeping of heavy jigs and fixtures at the machines which use them intermittently (as boring jigs at horizontal borers and turning fixtures at heavy lathes), but *only if the jigs and fixtures are card-indexed for periodical inspection.*

In most general engineering shops too many jigs and fixtures are kept on the shop floor. In the process of recording all jigs and fixtures in the works, if this is not already done, a location procedure for each one should be decided upon in terms of frequency of use, accuracy of operations performed, accuracy of the item itself, and cost of handling.

TOOL-MAKING AND MAINTENANCE

It is not unusual to find a tool-maintenance department running on machines used up and no longer needed by the shops. In the works employing up to about 500 people this may be the tool-room as well as the tool-maintenance department; in larger works the tool-room may be separate. But, whatever the lay-out, one would expect to find machines more accurate on the whole than those in the shops.

It is worth while having a thorough instrumental check-up on the machines in the tool-room (see Chapter XV) to put each machine on a planned inspection basis.

It is here suggested that no drill, tap, die, reamer, broach, hob, milling cutter, or form tool grinding by hand be allowed in the operating departments or, in fact, elsewhere. It is a pleasant fallacy among "old hands," tool-setters, and foremen that they can grind tools of this class "to cut to a tenth of a thou." or "to last longer and cut better than . . ." The carrying out of this suggestion will mean equipping many tool-rooms with machines they do not have. In fact, the idea that the main equipment of a tool-room is made up of centre lathes, a slotter, a universal miller, a universal grinder, a surface table, a drill, a vice, and multiples of these for gauge and jig and fixture making is all wrong if equipment for tool maintenance is absent. How many works, for example, have a first-class universal miller, or a jig borer for jig-making, in the tool-room but have no machinery, or inaccurate machinery, for drill, tap, and reamer maintenance?

ESSENTIAL EQUIPMENT

Fair equipment for tool-making and maintenance and simple jig work is as follows—

Tap grinder (flute and lead-in).

Drill grinder (with reliever).

Turning-tool grinder (for tungsten carbide).
Electric hardening furnace.
Centre lathe.
Universal grinder.
Universal miller.
Drilling machine.

TOOL-MAKING AND MAINTENANCE TOLERANCES

Over the past ten years the writer has asked jig designers, tool-room foremen, and tool inspectors to what standard of accuracy jigs are made relative to the accuracy of the part to be jigged. We have not room for all of the various answers here, but they varied between (*a*) "We work to a tenth of a thou." and (*b*) "We keep to work tolerances."

It is unfortunate that there is no standard published guide on this matter; the writer, however, has found the following general rule useful: *Tolerances between spaced holes, slots, or faces should, on the jig counterparts, be one-quarter of the tolerance on the workpiece.*[1]

It is essential that those companies making their own taps, reamers, jigs, dies, and the like, work to definite standards of accuracy. In those companies making their own gauges it is even more important (see Chapter IX).

Standard angles for drills, taps, turning tools, and cutting tools generally should be accepted for various types of metals. There is no virtue, even in the smallest company, in not working to economic practice.

MACHINE AND TOOL PURCHASING AND MAKING ECONOMICS

Often enough the investigator will find non-factual thinking at the root of tool buying and making. To guard against this the sponsors of the new tool should be required to give all essential information.

[1] Standards exist for jig hole and bush diameters.

Factors to be considered before a decision is made on purchasing of new machinery are more than merely financial, and may include—

Comparison of new and old insurance, depreciation, maintenance, power, operating set-up, and overhead costs per workpiece to be done.

Comparison of new and old quality of work done.

Quality of new machine as shown in specification of materials used in its construction and the wear properties of these.

DIMENSIONAL SPECIFICATIONS FOR NEW MACHINES

There is a tendency among writers on machine selection (see Diemer's *Factory Organization and Administration*[1] and *Cost and Production Handbook*[2]) to stress financial and ignore engineering factors in this matter, with the result that the cost accounting angle is given undue prominence. To avoid this and, too, to avoid bias in the works, *any proposition for new machine tools should list all reputable makers and should cross-reference to and have attached material and dimensional specifications and output specifications as well as price for each make of machine.*

Decisions on whether to make or to buy jigs, fixtures, and gauges are more than merely a matter of apparent costs and convenience. Too often a company decides to make these, and, because the tool-room is an overhead cost, ignores the calculation of full tool-room charges against the tool. Again, some companies take on the making of jigs and gauges without full knowledge of requisite jig tolerances—this is just slightly worse than asking some other company to make the jig without asking for material and dimensional specifications.

[1] McGraw-Hill [2] Ronald Press.

MACHINE WRITING-OFF

The problems of—

(*a*) When machinery should be replaced, and

(*b*) When a new machine should pay for itself

are difficult in the extreme. It is good policy to attempt to purchase each year replacement machines to the value of 10 per cent of the "as new" values of all machines. Note that machines to meet increasing sales are not included.

If a machine is to be profitable it should pay for itself in about three years.

Jigs should pay for themselves in, at most, two years.

Gauges should be written off as follows: plug gauges and solid screw gauges in one year, adjustable gauges in three years.

Small tools, grindstones, lathe boring, slotting and like tools, drills, taps and reamers, files, screwdrivers, and hammers should be written off in one year.

TOOL CLASSIFICATION

The greater the number and variety of tools, the greater the need for classification. Numbering systems are not very satisfactory, and, it seems, a mnemonic system is best. Taking X in the main class (see Fig. 5, page 31), we could have—

```
A . . . X . . . Z
     Expense
        |
-------------------------
A . . . M . . . T . . . Z
     Maintenance Tools
                |
-------------------------
A . . . B . . . M . . . Z
  Boring Tools  Measuring
     (XTB)          |
--------------------
A . . . C . . . Z
       Callipers
        (XTMC)
```

FIG. 40. TOOL CLASSIFICATION OUTLINE

It is recommended that jigs and form tools for special operations take this classification, but these should also take the operation number (see page 27). In practice, the letters X and T of the foregoing classification need not be used in the shops, although it is necessary, in fact, to relate them to the base system (see Chapter V) if more than one system is to be avoided.

TOOL INSPECTION

Gauges and other measuring instruments should be checked on return from the shops (see Chapter IX); similarly with jigs, taps, reamers, broaches, hobs, and dies.

Dies may or may not be checked instrumentally; the others should as far as possible be so checked.

Arbors, mandrels, and spacing collars should also be checked instrumentally.

Turning tools should be inspected for cutting angles (with special gauge) and for wear.

Responsibility for gauge and tool inspection is usually with the inspection department operating in the tool stores.

Shop micrometers (kept by men or by foremen) should be inspected at regular intervals (see page 77), and shop tool kits should be checked for quality and quantity at defined periods (once in three months for turning tools and the like).

TOOL REQUISITIONING

In most engineering shops tool requisitioning falls under three heads—

1. Tool requisitioning for addition of existing type of tool to a recorded tool kit.

2. Tool requisitioning for new tools to be made.

3. Tool requisitioning for new tools to be purchased.

Under the term "tool" as used here are included jigs and shop small tools generally. The flow of the forms used will depend upon whose authority the tool maintenance and

the tool stores operate and on whether or not there is a process department.

In the smaller shop and in large general engineering shops, a great many ideas for new tools and jigs will come from the works management ranks. Ideas for jigs should be sketched out and sent for cost estimation, then should be sent to the costs department with details of savings before work is proceeded with in the drawing office.

Requests for new tools could be on a form such as that shown in Fig. 41. This is in triplicate: one copy is kept by the requisitioner, one copy goes to production control or to ratefixing (to ensure getting cost benefit of new tool when made), and one to the jig and tool draughtsman who draws the tool, costs it, checks against potential saving, and issues the drawing to the shop or to the buyer. Jig estimates for cost and saving he sends to the costs department. The issue of the tool when made is done only on the word of the ratefixing department.

TOOL REQUISITION

Please supply to dept. the following jig , tool
, to be used on Order No. , operation No.
Machine .
This is to replace

The advantages are:
Cost:
Quality:
Cost of item will be
Will be used times per on lots of
Age of present tool: . Tool No. Cost:
Sketch here (or attach sketch).

Date: Works Manager:

FIG. 41. TOOL REQUISITION FORM

When a new tool is one that can be made in the tool-room to shop sketch and the foreman and the works manager agree the tool is needed, then, in the case of special turning tools, spacing bushes, and like small accessories, the making should go ahead on the word of these works officials, and be booked to the proper tool order number. So, too, with small accessory buying, although in this case the word of the finance department is required before proceeding.

TOOL KITS

The problem of what tools, if any, a worker should have at his machine or bench is one which theory is apt to dismiss by suggesting that the worker should have only those tools necessary for the particular job in hand. Theory, in most engineering shops, must give way to sound practice, which suggests that while some jobs may be tooled up with special kits of tools, other jobs, and they are often the majority, will be tooled up from the operator's general tool kit which he keeps at the machine or bench.

Machine	Tools	Bonus Percentage
C. Lathe	89	24
,,	65	38
,,	45	25
Capstan	52	34
,,	28	18
,,	23	29
Bar Auto		
,,	75	29
,,		
,,		
,,	193	18
,,		
Rad. Drill	28	19
,,	16	17
,,	7	28

But it does not follow that because special tool kits are not greatly used, the worker should therefore have an uncontrolled general tool kit. It may be argued that a comprehensive tool kit means more output. The table shown on page 149 consists of actual figures selected from a tool-kit analysis of over 600 machine operators.

Quite recently, the writer, in conjunction with the works management and the foreman of a large shop, carried out a suggestion that the foreman should decide how many tools each man should have, then leave each man to make his choice within the determined number, with the right to protest against the number. This scheme was a remarkable success and got the full co-operation of the shop.

The chosen tool kit, in each case, covered tools of any necessary kind, spanners, hammers, oil cans, brushes, files, and the like. Each man signed (see Fig. 42) for this kit

TOOL AND ACCESSORY KIT

Machine: Dept: Men:
Date Issued: No. of Checks:
To be checked each
Signed:

Description	Symbol	Value	Replacements

FIG. 42. TOOL AND ACCESSORY KIT CONTROL FORM

(if a night shift was on, both men signed), and the kit became the property of the machine in the case of machine-men.

TOOL ISSUE AND RETURN PROCEDURE

The standard general kit for each machine or bench may have any worn-out item replaced by presentation of the item in question. Broken, damaged, or lost items of the kit should be replaced only on the foreman's signature.

Tools required over and above the general kit may be had on presentation of a machine check in the case of a machine operator, and a man check in the case of a bench or floor worker. In many companies it was found that the system of worker checks on machine work led to much difficulty when a night shift operated (breaking of set-ups and claiming of tools as personal property), and a change was made to a system of machine checks. Checks had to be left on the machine for the following shift, and a count by the shift operator of special tools, gauges, jigs, and checks sufficed for tool and check responsibility transfer.

A record of damaged, broken, and lost tools may regularly be kept (see Fig. 42) and information be abstracted at chosen periods for works control and for accounting purposes.

Where a punch-card system is used, all issues of new tools and replacement of damaged, broken, or lost tools may be coded up, punch-carded, and mechanically sorted and costed by kinds of tools, by departments, by varying periods, by jobs, or fairly well as one will (see Chapter XII, page 116).

Where at all economical an attempt should be made to issue the special tools, gauges, and jigs for any operation with the release of the material to the operation. This may be done where proper route cards (see Fig. 50, page 184) are kept and work progressing is central. Consideration of this aspect of tool issue and return is left for Chapter XX.

TOOL SALVAGE

There is little that is of practical value written on this subject, perhaps because the problem varies from one works to another. Thus, on whether or not a company uses all

tool steel turning tools, mild-steel shanks and brazed noses, tipped tools, or some other kind of design will depend the angle on turning-tool salvage.

In the larger engineering company (having about 500 or more people) it may be worth while considering getting out a standard procedure on tool salvage, although, to be logical, this should be preceded by an inquiry into the uses made of modern practices of tipping and metal-deposition for turning and other tools, tooth-insertion for milling cutters, reamers, saws, and the like in the works, and, in general, the effect of proper tool maintenance and inspection on tool life.

The writer knows of only three companies which have got out or are getting out standard procedure on tool salvage. These procedures cover plug gauge regrinding and lapping, slip gauge lapping and recalibrating, gauge plating and lapping, turning-tool tipping, drill and tap effective lengths, drill tap and reamer tang repair, and, in one instance, hammer, spanner, and file salvage.

At the moment no very dependable figures may be given of the savings from tool salvage, and it is left to each company to develop its own policy.

LOADING AND SCHEDULING IN THE TOOL DEPARTMENT

In those works where tool maintenance takes place in the same department as tool- and jig-making, the problem of work loading for production control purposes may not be easy. Yet, if planning is to be moderately effective, some control over new jigs and tools in terms of production flow will be necessary; as a basis, a load sheet or chart for each different class of machine and for bench work in the tool-room will be necessary. Where tool maintenance is done in the tool-room, it will be necessary to book x per cent of total normal machine hours on certain types of machines for this purpose.

The tool-room executive official usually keeps his own load sheets and from these gives delivery promises for new jigs and tools to planning on a delivery request form sent with the tool drawing. Each new jig or tool is routed, as is ordinary production work (see Fig. 50, page 184), and is covered by operation job notes and material notes.

The first need is a system of load sheets in the tool-room; the later development of route carding for tools may take place either in the process department (see page 182) or in the tool-room itself, depending on the size of the works. A load sheet such as that shown in Fig. 56 (page 200) will serve for each type of machine to be loaded; the technique of loading is as described in Chapter XX.

TOOL PROCEDURE COSTS

We are not here concerned with tool costs, but with the cost of tool receipt, storage, issue, inspection, recording, and maintenance. The figures quoted are actual and are *for non-mass and non-continuous production engineering shops machining most of the parts used in the assembled products they make; moreover they are for works which properly maintain shop tools.*

Types of Products Made in Works	Machine Hours per Week	Direct Employees	Tool Stores Staff	Tool Maintenance Staff
1. General light and heavy batch and singles . . .	35,800	950	5	9
2. As 1	24,200	780	5	6
3. As 1	14,500	432	4	4
4. Fairly regular flow of six types of job .	7430	278	3	2
5. As 1	3790	174	2	2
6. As 1	2580	102	1	1

The usual operating control ratios published to cover this kind of activity are nonsensical just because they tend to over-simplify the factors involved. The foregoing illustrates that tool procedure cost is related more to number of machine hours in works than to number of direct employees.

CHAPTER XVII

FITTING, MACHINE, PLATING, CASEHARDENING, FORGE WELDING, AND PATTERN SHOP ANALYSIS

WHEN the investigator has properly analysed quality control, inspection, material control, tool control, and maintenance, and has set in motion the techniques and mechanisms to put these on an engineered footing, he is then in the position of making a choice as to whether to go through with the job logically (processing, planning, job evaluation, ratefixing, in that order), or to direct his attention where it will bring the greatest immediate returns, and also to determine on the general programme of production department organization. For this, job analysis is invaluable.

JOB ANALYSIS

Job analysis is the logical study of a whole job or a whole operation; time or labour study (see Chapter XVIII) is the study of the elements of an operation on a job. Thus job analysis, covering as it does the operation on a job, or a series of operations on a job, plus the factors necessary to the doing of the operation or operations (materials, labour, the machine and small tools, location of machine to previous and next operations, and of material to machine and general conditions under which job is done), may include the use of time or labour study.

THE BASIS OF GOOD ANALYSIS

Effective job analysis of a logical kind is more important than stop-watch analysis of operations, but the analysis must be methodical. In other words—

1. It must start at the very root of the job and question everything.

2. When the analysis is of a whole department effectiveness it should break down the entire field to its factors and analyse each factor in logical order.

3. When the analysis is of a single job it should be as (2) above, and question the need for the job, the design, the material, the tools used, the doer of the job, and the situation of the job.

4. The time to be spent on analysis should be in terms of the present and future expense on the job and the probable savings.

5. Each factor in the analysis of a job should be considered in terms of probable saving. Thus, if a part is high-quality bronze and it costs more than the labour on the part, stress may be placed on material analysis.

6. The analysis must be factual, it should be put in writing, and it should be verified in its conclusions by the executive in normal charge of the field analysed.

USING THE SUPERVISOR

The job of the analyst is half done if he wins the co-operation of the supervision.

The genuine analyst will realize that—

1. Giving the existing supervision expression (often denied) will help considerably.

2. Being quite open about his reports and stressing the faults of things rather than of people helps the job.

3. Sharing the credit for work done will get maximum co-operation.

To be frank, in more than 50 per cent of the companies the writer has been in, the ideas put forward and gladly welcomed by the directors were, in large part, ideas that had previously been put forward by various executive officials but had been ignored or shelved.

Although organizers and efficiency experts do not in writing say so, the truth is that a large part of an organizer's

work is really the integration of existing ideas into a logical whole and the selling of these ideas to the directorate.

THE FITTING SHOP

It may be thought that the logical way is not the way of tackling the fitting shop first. This is true; but, on the other hand—

(*a*) The fitting and test processes when analysed will usually indicate where the major faults of earlier processes lie.

(*b*) It is usually possible to organize the fitting shop and to show considerable savings without waiting for the full organization of earlier processes. So with the paint shop and the dispatch department.

Regarding this latter, the writer, with the help of the management, has, in ten works covered in the past three years, shown savings in direct labour fitting cost of 82 per cent, 77 per cent, 72 per cent, 64 per cent, 61 per cent, 60 per cent, 58 per cent, 55 per cent, 47 per cent, and 38 per cent respectively, and produced a better article. These are cold, verifiable facts.

The best general method of tackling the fitting shop is to—

1. Make a list of all the products manufactured.

2. Get the sales department to sort out the list in order of sales importance.

3. In the order listed by the sales department make a thorough analysis of the whole job situation of each product, using the stop-watch from beginning to end and paying particular attention to—

3*a*. Method of giving operator instructions about job.

3*b*. How parts come to operator in terms of quantities.

3*c*. Location of parts.

3*d*. Cranage (waiting for), and handling generally.

3*e*. Tools: supply and location of, going for, borrowing, waiting for, grinding and touching up of.

3*f*. Marking-off, drilling, tapping and reaming by fitter; cleaning out holes and cleaning off scale and dirt by fitter. (Check up against drawings and, if necessary, check gauges and jigs used in machine shop.)

3*g*. All key filing, bore scraping, face filing, and scraping by fitter (check as (3*f*) above).

3*h*. In and out attempts at fitting parts.

The analysis should be laid out on completion under such headings as are shown. It will probably be found that—

4. Checking up all parts in finished stores (given tolerances are correct (see Chapter IX)) will prove the need for more control.

5. It will pay to double inspection for a time (but see Chapter X).

6. Handling facilities require revision.

7. It will pay to have parts binned complete to parts list before issue to fitter (except on heavy, long-time fitting).

If thorough analysis proves the need for fitting shop reorganization then

8. An offer of payment of the average earned for the past x months to the fitters during the period of reorganization is usually acceptable.

9. Extra inspectors can be chosen from among the fitters if that is possible; so with analysts and study men.

It must, however, be pointed out that there is little use tackling fitting if tolerances, quality control, and material control are not well in hand.

THE MACHINE SHOP

It is openly agreed that the only correct method of reorganizing a machine shop (and this includes such shops as press shops) is through the logical application of quality control mechanisms and methods, material control, correct handling and transport, effective maintenance, and good

tool control. These should be improved as far as is possible, then the problem of processing should be faced.

Although the fundamentals have previously been covered, it is worth while covering the main points of machine shop analysis for those readers who wish to base decision on future organization on a factual basis. Analysis should take the following lines—

1. Take sample of machines and check their effectiveness instrumentally (see Chapter XV).

2. Check up on sample machines' equipments.

3. Take thorough job analysis of *x* operations on a number of each type of machine, or, alternatively, take job analysis of typical operations (using the advice of the sales department) and question—

3*a*. Necessity for operation; suitability of machine for the job; type of labour.

3*b*. Tool angles and maintenance of these; tool set-up.

3*c*. Type and amount of material used, and shape for holding.

3*d*. Jigging, speeds, areas of cut.

3*e*. Job to machine handling times.

3*f*. Per cent of total time (floor to floor) in which labour is being utilized.

3*g*. Gauging method and times.

3*h*. Tolerances allowed.

3*i*. All filing, ragging and polishing times.

3*j*. Job back on floor or bench time.

4. Check up on general conditions: lighting, heating, ventilating and safety.

THE CASEHARDENING DEPARTMENT

This department is one of the Cinderellas of engineering works, and one seldom or never reads of the time study or the planning expert going great guns in it. Machine shops

are, comparatively, child's play to the stop-watch expert, but so involved are technical with production cost considerations in heat-treatment generally that, as one heat engineer put it, "the timing experts can be blinded by science." In fact, the release of the pure study engineer type of man in a heat-treatment department can do a great deal of damage.

A thorough job analysis of the casehardening (carburizing plus hardening) department would comprehend the following in the order given—

1. The process used in relationship to part type and function.

> 1*a*. The compounds used (if the solid compound principle is in vogue): the quality of charcoal and particle size, stability of the energizer (carbonate) and the control of the percentage of this to the mix, the effectiveness of the binder, the effective use of diluents.
>
> (The problems outlined above plus that of ratio of compound used to jobs done are of prime importance; the compound work ratio is important from the cost and time standpoint.)
>
> 1*b*. Design of containers from the standpoint of carbonizing cost and quality.
>
> 1*c*. Heating used (with packs); control of and standards for this.
>
> (Many of the foregoing points are significant of liquid carburizing as well as solid compound carburizing.)
>
> 1*d*. Quenching rate standards; quenching plant effectiveness; quenching procedure (note that this is a most important factor and one often ignored).

2. Controls during casehardening, use of spies for case depth, pyrometric controls.

3. The use of metal specification and the testing of metals prior to carburizing (lack of these can kill a carburizing department).

4. Design of furnace from standpoint of handling costs (fixed bed, rotary hearth, or pusher type).

5. Method of moving boxes to and from the furnace doors and of charging—modern plants are mechanized.

6. Method of mixing and handling compound.

7. Use of load records for each furnace charge and co-ordination of these with time, temperature, and process tests (spies).

8. Technical controls: indentation (for case), brinell (for core), and microstructures; frequency of these, if they are planned, and control records.

At this point a few studies of labour operations are in order, and the whole may conclude by a study of ventilation, lighting, and safety—a study very necessary in many case-hardening departments. If necessary, historical cost records on a cost per pound basis may be checked up for *x* period in the past, and for the present.

NORMALIZING AND ANNEALING DEPARTMENT

This could be treated as part of the casehardening department, but as it is, on the other hand, sometimes separate we treat it separately.

If we leave aside steel foundry and heavy steel mills, the labour factor in annealing and normalizing in the average engineering works is of small importance from the cost standpoint, and analysis will be concerned largely with methods.

Analysis of effectiveness, to be thorough, may have to cover a large field, for the potential variables in normalizing and annealing procedure are many; in both processes, efficiency will be greater the more variables are eliminated. Variables are size of job, job structure, quantity, carbon content, temperature, rate of process, fuel effect on atmosphere, the human factor, properties desired from process, etc.

It is unfortunate that in many works where heat-treatment is used there is only the haziest idea of the value of records and standard instructions on the different time and temperature requirements of castings, forgings, hardened steel and screw stock, for example, and of the value of laboratory tests and codified records of the effect of job size and shape on process method and time. It is in the direction of analysis of these factors and that of temperature control that the engineer analyst can, in the writer's opinion, do most good.

The problems of furnace design and handling techniques are similar in effect to those met with in casehardening.

THE FORGE SHOP

The forge shop is yet another Cinderella of many engineering works, and one does not hear much after the style of "how I saved 50 per cent in the capstan department" in connexion with it.

Job analysis in the forge shop should start off with technical considerations, because here, more than in the fitting and machine shops, the cost of wrong technical outlook and method may be much higher in the long run than the cost of wrong labour utilization.

Technical analysis requires some general insight into the problems of the effect of mechanical treatment in the hot and cold states on the physical properties of steel; hot working may be defined, in the case of iron carbon alloys, as work done above the critical range (above the A3, A3–2, and A3–2–1 points on the equilibrium diagram), and cold working as work done below the critical range.

It is unfortunately true that in many forges on quite important work there are no general standards covering the technical aspects of the process carried out. One does not expect the forge foreman to be an expert on grain structures, but when the foreman does not even know there is a critical

point for the steel he is working and he is not informed verbally, graphically, or in script, it is too bad, and the ultimate effect is apt to be disastrous. Thus, the writer suggests analysis should take the following line—

1. For each type of steel used is there a standard instruction as to working temperatures, referring not only to forging temperatures but, also, to *finishing* temperatures (this should be round about the critical range)?

(The tendency in mills is to finish work too hot, while in forges it is to start and finish too cold.)

2. Is there any pyrometric control during working?

(Absolute control for equal grain size throughout a forging is impossible, but, nevertheless, good general standards are better than comparative guesswork.)

3. Tackle furnaces as under casehardening (this chapter).

4. Consider run of jobs done, and consider effectiveness of forging equipment (especially on batch work).

5. Check up on present plant wear and tear.

6. Consider allowances for forging; check some of these on typical work.

7. Consider method of surface cleaning.

8. Check allowances for machining.

9. If above seem too high, check up on dies used.

10. Check number of diameters reduced during forging against number of diameters on finished work. Apply (8) above.

11. Check if drawings give definite instructions as to forging allowances, dimensions, and dies to be used (has the drawing office a list of dies?)

12. Check up on material issue.

13. Check up on work handling and placement.

14. Check up on forging inspection, if any.

15. Check up on lighting, ventilation, and safety.

16. Take studies of typical jobs.

THE WELDING SHOP

Here again technical considerations are of first importance, and, here again, we usually find the design departments shy of showing their hands—although not so shy as in case-hardening and forging. This lack of standards in the departments mentioned is usually the major, though not the most obvious, fault to be found.

To characterize the main welding process would require more space than we have to spare here; thus, we have forge welding, electric resistance welding, gas welding, atomic welding (hydrogen), and thermit welding. Of all of the processes developed, electric welding is the most widely used, and to this we shall largely confine ourselves, reference being made to metallic arc especially. What is here said, however, is significant of other processes.

Welding department analysis may take the following lines—

1. Are welds actually designed by the drawing office staff, or is weld practice empirical?

2. Is weld design based on known and proved standards?

3. Is there a standard code sheet and weld diagram sheet in the works; are "arc-amperes" covered?

4. Are welding materials (rods) bought to specification?

5. Does the designer when designing work do so on the basis of costs per pound of deposited metal and of machining costs? Does he know these costs for various types of joints, plate thicknesses, and size of electrodes?

6. Are largest possible weld rods used?

7. What are generator effectiveness; break-down costs; efficiency in the arc?

8. How is material issued? Who controls storage? Who requisitions for material?

(Too often the control is in the weld shop itself.)

9. At this point a full analysis may be made of typical jobs, noting especially—

9*a*. Possibility of reducing cost by keeping the welder on welding (use of helper for loading and unloading tables and jigs; use of proper jigs and fixtures).

9*b*. Work positioning for ease of welding (i.e. in the "down position").

9*c*. Amount of pedestrianism and handling of job parts.

(Most welding shops appear to suffer from lack of material planning and progress, and from bad handling facilities.)

10. Extend analysis to flame cutting as above, but note, also, the possibility of manifolding cylinders, regulator effectiveness, cutting tip effectiveness, cut tolerance, use of standards for orifices, oxygen pressures, cutting speeds, and gas consumption for various thicknesses of metal.

11. Extend analysis to spot welding as above.

12. Note effectiveness of safety and health devices (eye protection, clothing, fire protection, ventilating, and lighting).

13. Check up on use of (*a*) destructive and (*b*) non-destructive tests: (*a*) tensile, bend, specific gravity, impact and hardness, and (*b*) visual, stethoscope, X-ray, resistance, magnetic, and pressure.

(It is realized that the foregoing (13) is discriminatory analysis and depends on the size of shop and type of products.)

14. Check if there is a definite inspection system in the department.

THE PLATING SHOP

The chief criticism which can be directed against most plating shops is, as has been remarked of the heat treatment and welding shops, that the design department usually leaves material choice and job development to the plating shop foreman. Again, tools are too often out of date, and handling and material control often poor.

The reasons for the poor general effectiveness of many plating shops are that materials are often heavy to handle and are unwieldy, modern heavy tools are expensive, and

modern processing practice has not so far caught up with what may yet be called "the black shop."

Usually, the plating shop is split up into the template shop and the plating shop proper. Between these two is the drill or punch shop. It may here be said that for general purpose work which has to be assembled by riveting or by bolting up, drilling is usually cheaper than punching in terms of final cost.

Analysis in the plating shop may be as follows—

1. Does the drawing office develop all jobs and put the necessary data on the drawing so that the template maker has not to do trigonometry to lay-out the jobs?

2. Are overall burning, shearing, and plate planing tolerances standard?

3. Are hole pitch and angle tolerances given the template maker?

4. Has the drawing office a list of standard templates?

5. Who decides when and when not a master template should be used?

6. Is there a template store with a system of records?

7. Is material store under proper control? How is material withdrawn and debited or credited?

8. What standard exists which states when a certain area of plate is scrap? Does this vary with thickness of plate? Similarly with channel and angle iron.

9. Check up on handling from yard to shop and handling of plate and structural steel within shop. Is a portable power crane indicated?

10. Check up on handling costs.

11. Check up on burning, punching, shearing, nibbling, drilling and other equipment. Check up on tools and feeds and speeds where necessary.

12. Make job analysis of individual operations, noting carefully the effect on welding, riveting, or other assemblies of quality standards at previous operations.

13. Check up on labour utilization.
14. Check up on inspection techniques
15. Check up on health and safety matters.

THE PATTERN SHOP

Elsewhere the writer has dealt with the pattern shop,[1] but a few important points may be made here—

1. How are patterns stored and recorded? Can one easily find any pattern with its loose pieces and core boxes, if any?

2. What control is there of patterns out? Is there a progress record?

3. Are patterns checked both out and in? (In the writer's opinion, if patterns were thoroughly checked out and in, a lot of grief would be saved.)

4. Who authorizes pattern alterations? How are these recorded? (Here again, much grief may be avoided by thorough method.)

5. Is any attempt made to plan pattern making? E.g. who decides on when a full or a half-pattern or core box is needed, when a "built-up," frame, or solid pattern is needed, when a wood, metal, or composition pattern is needed, etc., etc.? A check up on existing patterns may be illuminating.

6. How is pattern-making material stored and controlled? How released and recorded?

7. Are shrinkage allowances rule of thumb or standard?

8. Are draft allowances standard?

9. Make a thorough job analysis of typical pattern-making jobs, noting, especially, if any manual operations could be mechanized effectively (e.g. would a universal pattern miller help, if not used, or a bobbin and disc sander?).

10. Check up on machine tool effectiveness.

11. Are control times used on pattern making? If so, check these.

12. Check up on health and safety precautions.

13. Check up on labour utilization.

[1] *Foundry Organization and Management* (Pitman).

TECHNICAL CONSIDERATIONS

In those works having such processes as casehardening, normalizing, annealing, tempering, and welding, such an analysis as this will prove the necessity for taking technological factors into consideration before letting loose the "hounds of time study and rate-setting." To take only actual cases from practice.

1. A company organized its shops, and, among other things, showed a saving of some 20 per cent on grinding labour cost; after a large trouble bill had accumulated it was found that the new grinding techniques were reducing hardness numbers by as much as 8 per cent.

2. A bonus system was put into a hardening shop where temperature controls and records were poor; it took the services of an expert technician to get back to the very ordinary quality existing prior to the speed-up.

Machine shops and fitting shops are fertile grounds for management cost "scientifics"; we should be wary, however, that engineering fundamentals are correct in less fertile but equally important departments before applying organizing techniques.

CHAPTER XVIII

TIME STUDY AND RATEFIXING DEPARTMENT

THE fixing of operation times and prices in engineering works may be the result of various methods—

1. Comparative method, as when reference is made to operations similar, or nearly similar, to that to be rated.
2. Calculation method, as when times are calculated from speed and feed and job data plus comparative method for handling times.
3. Overall timing, as when the rate is a result of overall timing of a number of the operations.
4. Time and motion study, as when the operation is analysed into its elements and each element is timed by stop-watch (or camera) in a number of cases, each element is analysed, and the whole built up into a base time for the job.
5. Labour study, as when the preceding method is used but the operator is rated for speed and effort on each element.
6. Synthetic, as when base times are built up from constants derived from time and motion study or labour study.

We shall touch on these methods later in this chapter.

RATEFIXING EFFECTIVENESS

There are, unfortunately, no schools for the teaching of practical ratefixing, with the result that many works depend upon promoted machine and bench hands who, despite their general high skill, lack knowledge of the full ratefixing technique.

The following facts resulted from questioning twenty-eight ratefixers and eight process engineers in nine works—

(*a*) Not one could produce codified data in daily use to cover cutting tool angles.

(*b*) Only two had codified data relating cutting speeds to metal tensile strength and/or brinell.

MANUAL JOB ANALYSIS Sheet No :

Date: Time: from to Analyst:

Job No.: Item: Name:

Operation No.: Description:

Drg.

1. Operator: Age: Experience:

Rate: Work Effort:

2. Tools Used:

Remarks on Tools:

Crane Used: Slings: Fixture:

or Job Wt.:

Detail	Time	Lay-out Sketch
Filing		
Scraping		
Chiselling		
Cleaning		
Tap, Drill, Ream		
Lifting		
Lowering		
Going for		
Waiting on		
Oiling		
Painting		
		Remarks:
Total		

FIG. 43

(*c*) All of them put much the same fatigue allowance on the job whether the operation called for manual effort for 100 per cent of the operation time or for 25 per cent of the operation time.

(*d*) Seven only were able to handle effectively the setting of rates on machines, two or more of which were worked by one operator.

Sheet No.:

MACHINE JOB ANALYSIS   Dept.:

Date: Time: from   to   Analyst:

Job No.:   Item: Operation Name:

Operation No.:   Description:

Job Wt.:   Drg.:

1. Operator: Age: Experience
   Rate: Work Effort:
2. Machine No.:   Type: Age: Drive:
   Condition:
3. Material: Brinell: Allowance:
4. Batch Quantity: Usual Quantity:
5. Gauges:
6. Tools No.:   H.S.:   T.C.:   Types:

7. Jig or
8. General Kit:

Detail	Time	Cut No.	No. of Tools	Speed	Feed	Area of Cut
Cutting time Machine handling Checking Job to and from machine Gauging Total						

Conditions: Remarks:	Grinding, gear cutting, or other detail

FIG. 44

(*e*) In only two of the nine works were machine capacity charts in use.

(*f*) In only one of the nine works were constants being

used, and in this one the constants were few and of little real value.

It is essential in all but small works that ratefixing, whatever the method, be backed by (*a*) machine capacity charts giving all feeds and speeds, (*b*) charts for standard tool angles, (*c*) accepted and proved tables of speed of cutting metals with high-speed and tungsten carbide tools, (*d*) if possible, maximum area of cut for various metals on groups of like machines at known speeds for high speed and tungsten carbide tools, (*e*) tables of welding speeds for various welds with different size rods if welding is done as a production operation, (*f*) data sheets for machine, fitting, welding, forging and similar operation elements, or, as in comparative ratefixing, of whole jobs with sketches, feeds, speeds, tool set-ups and times, (*g*) a file of chosen literature on ratefixing matters.

THE TIME STUDY BOGEY

We may grumble at times at the practical shop-bred ratefixer, but the continual nuisance in general engineering works is the time and motion study fanatic who specializes on Bedaux or on something like it and knows as much about shop practice and shop psychology as a duck knows about the quantum theory.

No doubt the stop-watch specialist is at home among girls and unskilled workers on inspecting ball bearings, dipping chocolates, assembling screen wipers and vacuum cleaners, but, in general engineering and like work, he is not only a costly ornament but may be a menace to shop peace.

There are, alas, some engineer devotees of management scientifics who can swallow the following from a recently published American book on time and motion study[1] with not even a smile—

Moving finger, hinge movement at the knuckle, and measuring

[1] *Applied Time and Motion Study*, Holmes (Ronald Press, New York).

from the finger-tip with a total movement of 0 in. to 2 in. through 5 degrees takes 0·0017 min., but 4 in. through 10 degrees takes 0·0021 min.

Moving the eye socket 0 in. to 2 in. takes 0·0050 min., but moving it 4 in. takes 0·0055 min.

Perhaps the author of this book is correct in what he says (though there is no real biological justification for this standard measurement of physiological movement), but it is noticeable that here, as in every single book on scientific time and motion study read by the present writer, the author, when he deals with fatigue and like allowances wallows in a sea of "ifs," "buts," "nearlys," and "abouts" which put his four-decimal-point readings to flight.

Time and motion study has good uses in many shops, but, like the other numerous tools, methods, and mechanisms jumbled under the name "scientific management," it needs lots of experience, common sense, and tact for its successful use in engineering and like works.

TIME STUDY METHOD

As stated, this method is useful if wisely used, but mere dexterity with a stop-watch or a camera is the least important aspect of the full method. Thus, two equally well-trained time-study men produced accurate studies of the fitting of a machine-tool tail stock, but one analysed for 58 per cent saving in labour cost and the other only 16 per cent. The personal attitude was the factor which differed. For this reason the author insists that the capacity for keen job analysing (see Chapter XVII) is more important than is stop-watch accurate manipulation.

The seldom-mentioned weakness of orthodox time study method is that it requires a standard work cycle, for the work cycle is first standardized, then a number of studies are taken and the times for each work element compared (see Fig. 45).

TIME STUDY SHEET

Time: to Date: Observer: Study No.:

Operation:

Dept.: Tools:

Conditions: Operator: Skill:

Remarks:

Elements													Min.	Avg.	M/c Cycle
Totals															

Base Time: Delays: Allow: each

Fatigue Allowance: Personal: No. per Hour:

FIG. 45. TIME STUDY BLANK
(Usually foolscap size)

LABOUR STUDY METHOD

On batch and jobbing work the labour study method (Fig. 46) is useful. With this method each element is written down as it occurs, is timed, and the speed and effort of the operator is rated in terms of a normal rating of 60. The rating of 60 is normal day work speed (walking at $2\frac{3}{4}$ miles per hour, for example), and 80, if $33\frac{1}{3}$ per cent bonus is to be earned, is normal bonus speed (walking at $3\frac{2}{3}$ miles per hour, for example). Each element time is then brought to normal as follows—

$$\frac{\text{Actual Time} \times \text{Rating}}{\text{Normal Time (60)}}$$

To the above a fatigue and personal allowance is added. A labour study board with an element and an overall timing watch is shown in Fig. 47.

It will be noted that with time study the study man must pick an "average" man, which is equivalent to rating. Time study, however, is useful only for short-cycle repetition work, and on general work the labour study method is the most useful,[1] though not very accurate.

THE COMPARATIVE METHOD

It is the fashion for devotees of management scientifics to deride the method of setting a rate for one job by comparing it with another nearly similar job previously rated; but what would you do on one to six-off jobs, especially on fitting work?

The comparative method, however, may have many weaknesses, the chief of which is that it may repeat and multiply past rating errors. Nevertheless, if all the operations are broken down *on standard ratefixing sheets* before rating, and each element is taken separately for comparison, the

[1] Actual study method and training for study work are dealt with in the author's *Training in Foremanship and Management* (Pitman).

LABOUR STUDY SHEET

Time: to Date: Observer: Study No.:

Operation:

Dept.: Tools:

Conditions: Operator: Skill:

Remarks:

Element	Time	S. & E. Rate	Allow	Element	Time	S. & E. Rate	Allow
Total				Total			

M/C Cycle: Base Time: Allow: each

Lab. Cycle: Fatigue Allowance: No. per Hour:

Delays: Personal:

FIG. 46. LABOUR STUDY BLANK
(Usually foolscap size)

weakness of the method will be reduced; then the ***standard ratefixing sheets should be filed.***

The operation break-down need not be minute, but it

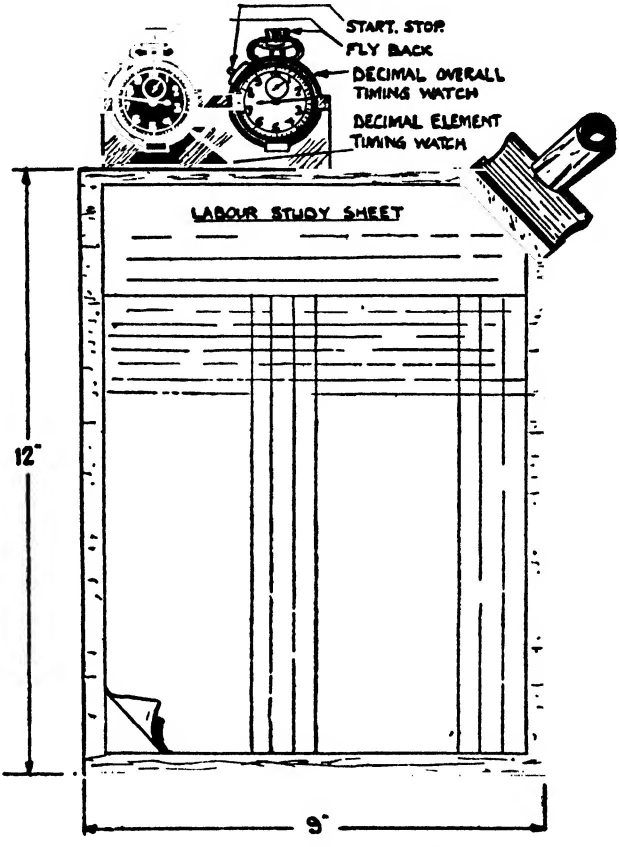


FIG. 47. TIME STUDY EQUIPMENT

should be such that it shows just in what respect a job is different from a previous job and in what respect the same.

THE CALCULATION METHOD

This method is widely used on metal cutting, welding, forging, and like work. In machine shops, cutting times are

calculated on the basis of certain feeds, speeds, and depths of cut, and, usually, setting up and handling time is based on codified or uncodified experience.

This method should have as base such a speed and feed table as is shown in Fig. 48, and, on setting and handling time, should be based on constants derived from stop-watch observation. Done in this fashion the method can be economical and reasonably accurate.

THE SYNTHETIC METHOD

This method, if not pursued to the 0·0017 minute for a nerve impulse to travel from brain to hand stage[1] (from which the Lord preserve us!) can be exceedingly useful. It is doubly useful in that it can be used with other methods.

First of all, it is necessary to open a card file for the reception of constants, and, next, it is necessary to collect constants by time or labour study. Where stop-watch study is fairly regular, an analysis of each study should be made for constant derivation.

To take a case in point, in the setting-up of automatic lathes, in six of nine works a general allowance of about 2½ hours on chuck work was made, in two works a general allowance of about 2 hours was made, and in the remaining works times varied between 25 minutes and 4 hours, with an average of 1¼ hours—in this last either direct study or synthetic rate-setting from constants was used. The machine types and sizes and the kind of work done were quite comparable in all nine works.

Constants for preparation time, getting tools and gauges, grinding tools, and mounting and setting tools are not difficult to collect, nor are general fitting, welding, forging, painting, and sheet metal work constants difficult to get out. Be wary, however, of other people's constants derived under unknown conditions; they seldom fit different work situations.

[1] See page 173.

— CUTTING SPEEDS —

MAT^L.	BRINELL	TURN & BORE High Speed Rough Feet/Min	TURN & BORE High Speed Finish Feet/Min	TURN & BORE Tungsten Carb. Rough Feet/Min	TURN & BORE Tungsten Carb. Finish Feet/Min	PLANE High Speed Rough Feet/Min	PLANE High Speed Finish Feet/Min	MILLING High Speed Rough Feet/Min	MILLING High Speed Finish Feet/Min	TAP High Speed Feet/Min	REAM High Speed Feet/Min	DRILLING High Speed Feet/Min	DRILLING Drill Sizes	DRILLING Feed Per Rev
Steel	100	125	175	350	750	40	20	90	110	40	60	100	0-1/8"	.001" to .002"
Steel	175	100	150	300	400	35	20	60	70	35	45	70		
Steel	225	80	120	225	400	30	15	40	50	25	40	60	1/8"-1/4"	.002" to .005"
Steel	260	60	80	130	280	25	15	30	40	20	30	50		
Cast Steel	115	100	130	250	400	45	20	45	55	45	35	50	1/4"-1/2"	.005" to .008"
Cast Steel	180	75	100	200	350	30	15	20	25	20	25	40		
Cast Iron	180	80	120	260	350	50	25	60	70	25	40	130	1/2"-1"	.008" to .016"
Cast Iron	220	75	90	200	250	40	20	20	25	20	40	70		
Bronze	55	220	300	500	750			60	70	40	40	300	1"-1½"	.016" to .020"
Bronze	95	120	200	300	500			45	55	25	25	200		
Brass	35	300	400	800	1000			110	140	75	90	300	1½"-2"	.020" to .027"
Brass	60	200	260	500	800			70	90	35	75	400		
Aluminium	8 Ton □"	800	950	1600	2500			700	900	100	120	500		
Aluminium	11 Ton □"	600	800	1000	1500			550	750	50	100	400		
Stainless Steel	37 Ton □"	70	90	140	220			25	35	15	35	70		

TURNING AND BORING IS GIVEN FOR GENERAL WORK ON FORGINGS, STAMPINGS AND CASTINGS.
ON CLEAN, SCALE FREE WORK, INCREASE SPEEDS ON TUNGSTEN CARBIDE BY 15%
NON-PILOTED BORING REDUCED SPEEDS BY 10%
ON MULTI-TOOL SET-UPS REDUCE ALL SPEEDS BY 10%

GRINDING

EXTERNAL

Work Speed:- 60 feet/min.

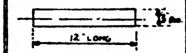
Table Traverse

Roughing:- 2/3 width of wheel per rev.

Finishing:- 1/3 width of wheel per rev

Feed:- .00075" average

Example



Width of wheel = 2"
Stock to remove .018"
Work tolerance .001"
Floor to floor 18 mins
Bonus time 16 mins

INTERNAL.

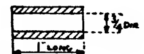
Work Speed - 100 feet/min.

Table Traverse

1/8 wheel width per rev. of work.

Feed - .00025" average

Example



Width of wheel = 3/4"
Stock to remove .010"
Work tolerance .001"
Floor to floor 1¾ min.
Bonus time 2½ min.

FIG. 48. FEED AND SPEED TABLE

THE ALLOWANCE PROBLEM

Elsewhere, I deal exhaustively with fatigue and other allowances.

The following allowances are reasonable and work out quite well—

1. Light repetition work, seated: 8% fatigue and personal (F. and P.).
2. Light repetition work, standing: 10% F. and P.
3. Light jobbing work, seated: 10% F. and P.
4. Light jobbing work, standing: 12% F. and P.

To above, if work cycle time is—

Secs. . . .	140	120	100	80	60	40	20	10
Add per cent .	0	0·15	0·27	0·4	0·6	1·0	1·6	2·5

Additional allowances are—

Fumes, dust, poor light	add	2	per cent
Bent or awkward posture	,,	2	,,
Lifting—per 100 ft.-lb. per min. . .	,,	3	,,
Females and youths	,,	6	,,
Carrying per 100 ft.-lb.	,,	0·3	,,
Females and youths	,,	0·6	,,
Pushing and pulling per 100 ft.-lb. . .	,,	0·2	,,
Females and youths	,,	0·4	,,

Contingency allowances should be the result of study. A claimed time system should cover waiting for work, breakdowns, and the like.

RATEFIXING ORGANIZATION

In the smaller works having about 200 people, ratefixing is usually controlled by the works manager. There is not, in practice, much wrong with this, although the writer has found it profitable to put the control of ratefixing (and simple processing) under the head draughtsman and to locate the ratefixing function in the drawing office.

It is essential, as already noted, that there be properly recorded and filed data covering all of the processes ratefixed in all the works; whether these be for synthetic or

comparative application does not affect the issue. There is sometimes too much of the "little black book" in ratefixing, and, when a ratefixer leaves, he takes in his little book data which should be an official record.

Useful aids will be found in a time alteration request form, used by foremen, and in a ratefixer's protest form. This latter is used by the ratefixer and is sent to the general manager via the production engineer when a high time has to be set because of poor plant, tools, and materials.

The ratefixing department, in the absence of a personnel department, should keep a card record of each bonus worker's earnings and of scrap and reclaimed work.

COST OF RATEFIXING

Where comparative or calculated ratefixing is used almost exclusively the cost for ratefixing is less than when time or labour study is general; on the other hand, the latter is generally the cheaper in terms of cost per £ of saving.

In general engineering works, of an average of nine engaged on one offs up to about twenty-five offs, the ratefixing to machine shop direct labour ratio is about one ratefixer to sixty operators when only the comparative or calculation method is used. The use of synthetic times is even cheaper, but the cost of collecting data will be high if done in a short period. Where time or labour study is used, and it is economical, the ratefixer to machine operator ratio will come out at about 1 to 45. On small and large batch repetition work with about 10 per cent specials the ratefixer to machine operator ratio will be about 1 to 60 if time or labour study is used.

CHAPTER XIX

TO PROCESS OR NOT TO PROCESS

PROCESS engineering is that function of engineering which determines how work shall be done; product engineering, i.e. design and drawing, determines what work shall be done. In short, the drawings of the products parts pass to the process engineer who—

(*a*) Checks design from the standpoint of works capacity and skills and from the standpoint of part function.

(*b*) Lists operations on each part and for each.

(*c*) Decides on class of machine or, if non-machine, labour.

(*d*) Decides on jigs and special tools needed.

(*e*) Decides on tool set-up, feeds and speeds.

From this point the ratefixer takes over and sets rates for each operation, the jig and tool designer goes on with his part of the job, the production planner ties the job up to shop load, and the progress engineer progresses the job through the works.

ECONOMICS OF PROCESSING

It is agreed that the statements about processing by academic writers on organization and by people whose chief experience is of continuous, or semi-continuous, production should be taken with the proverbial grain of salt, but, on the other hand, it should be agreed that decision on whether or not to process any job should be decided on the merits of the job.

There is no definite rule about when or when not to process, nor about how far to go with processing. If decision by a specialist on operation sequence will help deliveries and keep down work in progress investment, if decision on

jigs, tools, feeds and speeds, or only on the first of these, will reduce total cost, then, indeed, processing is required.

Thus, a company will process just as much as it will pay to process, but, it should be kept in mind, processing may do more than reduce direct labour cost through operation sequence planning and jig and tool and feed and speed decisions; it may also reduce working capital tied up on the floor, decrease scrap, and increase machine utilization. All of these should be balanced against the costs of processing.

SIMPLE PROCESSING

When the part drawing is finished and checked it is a fairly simple and economical step to break the job down to its operations on a route card (Fig. 50). The study of number off, likely labour cost, and quality standards will then aid decision on new jig and fixture initiation.

Ratefixing will follow, and, finally, dates for the operations to be done will be entered.

Without operation processing it is not feasible to run an elementary progressing system, and, too, it is difficult to keep a proper system of records.

This system of operation processing is quite suitable for work of such a nature as is done in a tool-room, therefore it is obvious that it is applicable to both small and large companies on one off and batch work. When it is considered that many companies employ a ratefixer yet have no formal method of recording operation sequences, despite the fact that the ratefixer has to rate-set each operation, it is obvious that the use of a route card will cost very little extra. We shall return to the need for route cards in Chapter XX.

TOOL PROCESSING

It is generally written that processing of the tools to be used and the setting of the tools for any operation should be accompanied by feed and speed processing (Fig. 51). This

ROUTE AND COST CARD

Job: Op. No.: Drg.:

Matl.: Quantity: Matl. Cost:

Operation	M/c Type	Lab. Grade	Insp'n	Set Time	Time Each	Hours / Cost	O'head	Total

Fig. 50. Route and Cost Card

is not so, for in most works, it will be found more economical to process tools and tool lay-out and to leave feeds and speeds to foremen (backed by good tabular information, see Fig. 48).

If we are quite honest with ourselves, it will be admitted that most speed and feed processing on single tool and, especially, multi-tool operations is empirical or is derived by process men from speed tables which are usually very general indeed.

PSEUDO-SCIENTIFIC FEED AND SPEED PROCESSING

There has been in the past few years a spate of writing on the timing of metal cutting from the chip pressure point of view. It was rightly claimed that the method of calculating from feed, speed and depth of cut ignored whether or not the machine was working to full capacity; it was suggested that the aim should be to get maximum capacity from the machine, the theory being that if chip pressure between the tool and the work is known the horse-power may be found. If, then, we know the horse-power transmitted at various machine speeds we may work out the various maximum chip pressures for various metals at these speeds.

The *Cost and Production Handbook* quotes the following—

$$P = C\,A$$

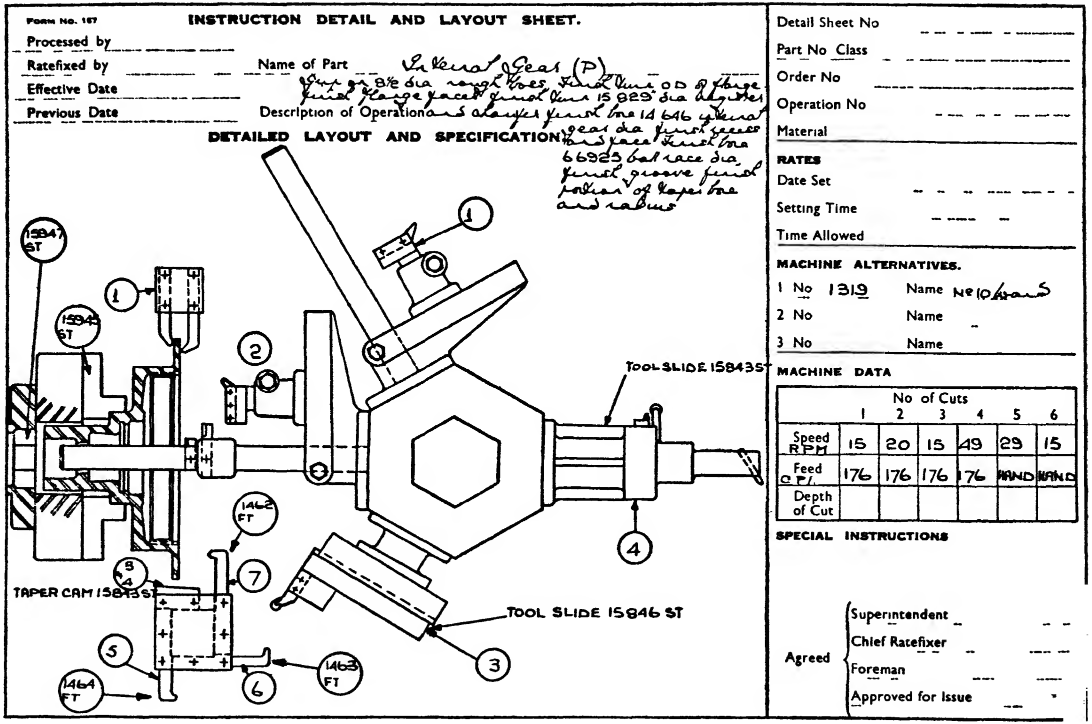
in which P = chip pressure in pounds.

A = sectional area of chip in square inches; it is product of depth of cut and feed per spindle revolution.

C = a constant, depending on material being cut.

This book then gives values of C as follows—

340,000 lb.	per square	in.	for high-carbon steel
260,000 lb.	,,	,,	for mild steel
130,000 lb.	,,	,,	for cast iron
185,000 lb.	,,	,,	cast steel
115,000 lb.	,,	,,	bronze



FORM No. 167

INSTRUCTION DETAIL AND LAYOUT SHEET.

Processed by

Ratefixed by

Effective Date

Previous Date

Name of Part Internal Gear (P)

Description of Operation Grip on 8½ dia rough bore, finish turn OD of flange, finish flange face, finish turn 15 929 dia together and chamfer, finish bore 14 646 internal gear dia, finish recess and face, finish bore 66925 ball race dia, finish groove, finish portion of taper bore and radius

DETAILED LAYOUT AND SPECIFICATION

Detail Sheet No

Part No Class

Order No

Operation No

Material

RATES

Date Set

Setting Time

Time Allowed

MACHINE ALTERNATIVES.

1 No 1319 Name Nº 10 Ward

2 No Name

3 No Name

MACHINE DATA

	No of Cuts 1	2	3	4	5	6
Speed RPM	15	20	15	49	29	15
Feed CPI	176	176	176	176	HAND	HAND
Depth of Cut						

SPECIAL INSTRUCTIONS

Agreed
- Superintendent
- Chief Ratefixer
- Foreman
- Approved for Issue

FIG 51 TYPICAL PROCESS LAY-OUT

Horse-power at cutting edge is then—

$$H.P. = CAS/33{,}000$$

in which $H.P.$ = horse-power and S = cutting speed in feet per minute.

The values of C appear to be four times the ultimate tensile strength of an average kind of each material (although there is no theoretical reason for this), but, in any case, the limitations of the materials shown make the table of little or no practical value; consider, for example, the difference in chip pressure of a cast iron of brinell 160 and one of brinell 220. Again, in bronze, variations are very much greater.

To add a finalizing touch to these hints on ratefixing the *Cost and Production Handbook* suggests that when we calculate the allowable power to be transmitted through gearing we should use the obsolete but simple Lewis formula. It adds one safe working stress for steel gears, yet, in fact, British Standard Specification No. 436 gives 35. Perhaps the point will be clear when we consider that gears may be made from steels varying between 25 and 120 tons tensile.

The foregoing is here mentioned because in the past three years the writer has come across production engineers in three companies trying hard to use this kind of non-factual information with the result that rates were actually being set worse than by the method of experience. The method is spectacular but, in fact, it is an attempt to put across information which any good research engineer would agree is not yet reliable enough for general use.

COMMON-SENSE FEED AND SPEED PROCESSING

Given that drawing dimensions and statement of finishes do not limit the process engineer, how is he to know what is the maximum capacity of various types and sizes of

machines on the cutting of different types of metals? The writer has found it useful to write to machine suppliers asking for maximum area of cut at stated speeds on various metals on each type of machine in the shop, but

in most shops it will pay on ordinary capstan and auto lathes, and on drilling, planing, milling, slotting, and shaping machines, to take close observations when opportunity arises of the best controlled tool performances on the metals commonly used in the shops. Speeds chosen should be from machine makers' tables, tool angles should be correct, and conditions should as far as possible be so controlled that the single variable to be sought is total area of cut per revolution or per stroke as the case may be—this applies to multi-tool and single tool work.

PROCESSING ORGANIZATION

In the average works the process engineer is best placed alongside or near to the draughtsman and the jig and tool designer. The writer has found that this best serves the purpose of low cost and effective production.

In the medium-size works the process engineer may be controlled by the production engineer, in the large works by the chief engineer, who also controls the drawing office, and in the small works by, it seems best, the chief draughtsman. This last may strike across established theory and practice, but, in fact, the writer thinks designing, drawing, processing, and jig and tool design should be under the control of one person. The difficulty is undoubtedly to get the right type of person to control all four effectively.

All new drawings should be passed to the process engineer for his scrutiny and decision from the production standpoint and for setting in motion such mechanisms as are necessary for doing the job economically—jigs, fixtures, special tools, and gauges.

The process engineer will also indicate the type of machine

to be used on machine operations and the grade of labour on all of the operations. For the jig and tool man he will sketch roughly what is wanted in the way of special tackle.

It is not usual to process tool lay-outs on single tool operations, but where multi-tooling is used, tool lay-outs are usually drawn and feeds and speeds noted.

The operations are then ready for the attention of the ratefixer, who rates each operation on the route card before passing it to the inspection planner (see page 84) if inspection planning is usual.

COSTS OF PROCESSING

The subject of the cost of processing affords interesting study, and the writer has collected a fair amount of particular and general costs which may be useful. The particular costs of processing, however, have not so far as he knows been dealt with previously in writing and, for that reason, should be accepted as data from a comparatively small number of companies—about twenty.

1. To process a product of moderate accuracy (tolerances down to 0·001 in.) with 25 parts and 150 operations, including the making of 80 drawings or sketches showing operation processes—300 hours. All feeds and areas of cuts were processed in this job.

2. To process a product of 57 parts and 290 operations, 192 process drawings, with moderate accuracy—702 hours; feed and speed processing included.

3. To process a product of inferior accuracy (tolerances down to 0·005 in.) with 24 parts (8 of these similar) and 78 operations, 36 process drawings—140 hours; speeds and areas of cut included.

The foregoing were all fairly repetitive products—on non-repetition small batch work the processing cost is generally cheaper (pencil sketches and no feeds and speeds) and a cut of 30 per cent on the foregoing could be expected.

In general engineering a fair average is one process engineer per forty machine[1] operators. Where operation and tool processing is being introduced for the first time, the cost will be higher than this if progress is to be made in covering the normal run of like or nearly like jobs in a reasonable time.

In good practice as applied to small and medium batch production, usually only multi-tool jobs and jobs set-up in gang will be processed; feeds and speeds may not be processed—the rate set for the job exerting a feed and speed discipline. Where this is the case, the cost of processing will be very small and the profit large if foremanship is good.

[1] This refers to multi-tool machines such as capstans and autos.

CHAPTER XX

HOW MUCH PLANNING?

It is not our intention here to attempt to outline those planning schemes which are supposed to give 100 per cent control of operation sequence and material movement by the use of sequence load boards and bar charts.

FALLACIES IN PLANNING

The greatest and most persistent fallacy in published planning schemes, and one accepted by engineering company after engineering company for a time, is that it is economically possible to use a planning board or a chart to lay out for some days in advance what will be the sequence of operations for, say, a general machine shop.

Let us say such a sequential lay-out is made for one week and the programme is upset by customer alteration, change in design, rush jobs, machine break-down, or what not, then every single line on the chart may have to be altered and every ticket on the board may have to be moved. Keep in mind that the withdrawal of a first operation on one machine means the withdrawal of, perhaps, a second, third, and fourth on other machines, and, on each line for each machine, each card will require moving and that will set up movement of all follow-on operation cards.

For the works with a defined single design of product, or even two designs, most of the parts for which are made for and drawn from stock to assembly, the method discussed above will work quite well; otherwise it is likely to be unworkable.

Yet other fallacies, not uncommon, are that a planning system can effectively be run without drawing office planning and that a progress system may be run without some method or other of loading.

PLANNING EFFECTIVENESS ANALYSIS

Although planning systems are not usually simple the analysis of planning effectiveness is simple—

1. Are deliveries good or bad; are more than 5 per cent of deliveries 5 days late?

2. Is the shop capacity in hours of different classes of output known?

3. Is there any recorded attempt at loading

 (*a*) departments, or (*b*) groups of like machines?

4. Is simple operation planning (on route cards) used? (In the small shop the route card may also be used for operation costing and, on repeat work, for cost control (see Fig. 50, page 184).)

5. Is a master history card kept of the flow of work on each special order?

6. If job notes for each operation are used (and they should be), can these be so dated and filed that they will form the basis of work progressing in terms of known loads?

7. What is extra overtime cost of getting out late orders?

As we stated earlier (Chapter III), reasonable planning will not only improve deliveries but it will be likely to decrease capital investment in excessive work in progress, make possible the taking of more orders, ease works management of the eternal burden of progress chasing and so free them for managing, and reduce overtime cost.

TOTAL LOAD SHEETS

Even if nothing else be done, the writer recommends very strongly that some effort be made at departmental total loading. Curiously enough, one can come across scores of companies using home-made and bought-out planning and progress boards of all shapes and sizes in an attempt to progress effectively without, however, knowing how the

shop load affects the progress dates in the first place. Again, there has recently been a spate of "visible index card" and coloured pins and beads progress systems with, usually, little improvement; indeed, the writer could mention three companies who spent on (*a*) a route card and job note duplicating system, (*b*) a complete set of steel cabinets, cards, and signals, and (*c*) eleven rather slick planning boards, respectively, the sums of (*a*) £1200, (*b*) £450, and (*c*) £145, when a simple system of loading plus job note dating would have accomplished much more and been more sensible.

BASIS OF LOADING

Loading must start shortly after the order comes into the works, for there is little purpose, as is all too common, in loading only after the drawings come into the shops.

For repetition orders the use of the load table is easy, for it is likely that past experience of like orders is recorded and load times may be abstracted for future use.

On special orders it is essential that the drawing office load be calculated when the design is drawn and before detail drawing starts (see Chapter VII). It is, however, true that in most general engineering drawing offices a load sheet of more than 80 per cent accuracy is unlikely. Such a load sheet, inaccurate though it be, will be very useful when used in conjunction with a drawing issue schedule (see Fig. 12, page 54).

THE ESTIMATE AS LOAD BASIS

Most engineering shops break down estimates on special jobs in such a manner that a base may be had for loading. This method, rough though it is, has much to commend it. Fig. 52 shows a typical estimate break-down.

Where estimating is done more thoroughly than is shown in Fig. 52, loading becomes fairly simple, the estimate providing load times for groups of like machines. Often

enough, if estimates are of the overall type, a check up of past cost records will give a fair guide for loading.

ESTIMATE	£	LOAD BREAK-DOWN Hrs.		
Drawing Office	56	480		
Fitting Shop	48	720		
Plating Shop	42	610	Weld	107
			Drill	35
			Templates	46
			General	422
Machine Shop	296	3810	Plane	337
			Drill	182
			Turn	1842
			Mill	472
			General	977

FIG. 52. ESTIMATE BROKEN DOWN FOR LOADING

PRICE AS LOAD BASIS

A rough-and-ready method of loading may be had from calculations from price. Thus, taking overheads on direct labour as, in total, 200 per cent, we could have for a typical product—

	£
Sales price	1000
Minus profit	120
	880
Minus material	380
Direct labour and overheads = 300% =	500
therefore 100% (direct labour) =	£ 167

This £167 is broken, by estimate, into hours, and is apportioned over the main shops.

The writer knows of two companies using this practice quite successfully in their works; unfortunately, it ignores the drawing office.

One other company has divided its products into classes, and, for shop loading, multiplies the price by a fitting shop factor, a machine shop factor, and a winding shop factor; when the price multiplied by, say, the fitting shop factor goes

above a certain amount the works executive officials know, usually rightly, that there is an overload.

ABSTRACTING LOADS FROM REPEAT ORDERS

Where work is repetitive *in its main aspects* it is fairly simple to get out the work load factors. The technique usually adopted by the writer is as follows. On a foolscap sheet all of the products are listed downwards, and across the sheet are listed the chief processes. By looking up past costs or past estimates the hours spent on each main process for each product are noted and used for future loading (see Fig. 53).

To sum up: (*a*) start a system of total loading somehow; (*b*) aim to total load every main process or group of like

Product	Fitting hrs.	Planing hrs.	Drilling hrs.	Capstans hrs.	C. Lathe hrs.	Welding hrs.

FIG. 53. SHEET USED FOR LOAD ESTIMATING ON JOBS NOT PURELY SPECIAL

machines; (*c*) include the drawing office; and (*d*) load up the day the order is received if this is at all possible. The fact that the total load may be only 60–80 per cent accurate need not stop the method from being tried.

EXISTING LOAD PROBLEM

When a loading system is being got out, one of the stumbling blocks is work already released from the drawing office.

Within the last two months one shop in the North successfully used the following technique. A list of all orders in the shops was got out, and an estimate made as to how

much of the work was finished. Then, if an order was 25 per cent finished, 75 per cent of known total hours required were split up among loaded processes in the ratio of normal hours of each process per month to all processes. This was rough and ready, admittedly, but in three to four weeks, major inaccuracies were smoothed out as work so loaded was completed.

A census of all work in the shops and of work released from the drawing office taken one week-end is the best method. So with work in the drawing office. Note well, however, that in a shop with four months' work in hand a method of total loading 70–75 per cent accurate is quite reasonable.

DETAIL SCHEDULING

Given that the load for each main process is known, it is simple to apply this to delivery date promising, for, it is obvious, the loads will inform the estimators when a job is likely to be delivered. This essential knowledge will remove one of the weaknesses of the majority of engineering shops: promising work in minimum time even when there is an overload.

Let us say, now, a job has been estimated for in terms of the shop loads and it comes in as an order due on a certain date. The next step is to have the job designed, then to issue a drawing release schedule (see Fig. 12, page 54) to the planner; the planner will roughly schedule the whole job out, check back on drawing release, and send the corrected form back to the drawing office, keeping a list of his schedule dates.

Before discussing this process further it will be necessary to define the process of scheduling. It consists of taking the delivery or the dispatch date and, by subtraction of operation times, arriving at the dates when operations should begin. These dates ultimately find their way on to route

cards, to job notes, or to load boards or sheets for progressing of work. Fig. 54 illustrates the idea of scheduling.

In some shops every operation is scheduled in detail, but, theory aside, it is almost impossible to do this in the average shop.

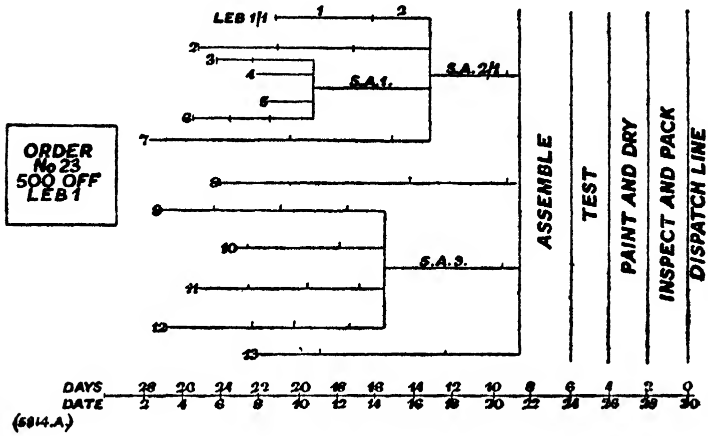


FIG. 54. IDEAL SCHEDULE

ROUGH SCHEDULING

The general shops running the best and most economical planning systems the writer knows, depend on rough scheduling backed by total loading.

When a design comes out it is broken down to discover how many parts must be bought out finished, bought out but to be machined at works, require patterns and/or castings, forgings, stampings, bar, sheet, etc. In terms of delivery date for the job in question each of these groups is scheduled to start at certain times in the shops and to finish at certain times at the assembling process, then, from these times, bought-out delivery dates, pattern drawing dates, and the like are arrived at.

In this rough-and-ready process heavy castings generally get preference, and light castings and light machine parts respectively are grouped to start and finish at certain dates.

This is the method of common sense, and it works if used with total loading. Note that the schedule is the basis of chasing bought-out material, drawing release, and work release into the shops.

STOCK SCHEDULING

When stock parts or products are put through, an order is made out and the various times for doing operations are loaded on to the various total loads, then the order is scheduled either in detail (this is easy for repeat parts owing to existing time records) or in the rough.

When finished parts are kept, stock orders will be met from existing stored parts, which parts are renewed in terms of a minimum quantity for each (see page 117). Semi-stock orders will have stock parts reserved on the parts list (page 202); other parts will be progressed.

SEQUENTIAL LOADING

At this point we may choose to make out route cards (Fig. 55) and/or job notes and progress as best we can in terms of the schedule previously made out, or we may attempt to fit operation dates into these loads. The latter is quite a reasonable method for many general engineering works but, for the small works, the former method is fairly good.

Sequential loading means that operations are loaded according to strict sequence. Thus, when the general schedule comes out it may state the exact dates for starting up important parts X, Y, and Z, but only one date may be given for general machine shop detail to get to assembly. The planning department may choose to break this general date down and actually to state dates on the route card for each operation as drawings come down. The girl who makes out the job notes from the route card makes out the last operation job note first, and, by subtracting preceding operation

ROUTE CARD

Order No.: Part: Part No.:

Drg.: Material: Material Quantity:

Operation	M/c Type	Lab. Grade	Inspection	Set-up Time	Oper'n Time	Schedule Date	Load Date	Remarks

FIG. 55. ROUTE CARD

times plus a contingency allowance for part movement and inspection, arrives at the date when each operation should start. This date goes on the job note, which may be used for progressing.

Yet a more detailed method is to run a load sheet for each set of like machines in the shop and for fitting, welding, and other necessary processes. This load sheet is made up on the basis of drawings received in the shop, and the operations are put on the load sheet in sequence and the load date transferred to the route card.

One sequential load sheet per separate load station is used, and usually the load is about one week ahead. A typical load sheet is shown in Fig. 56. Note that the total load which originates when the order is received is also used.

MASTER LOAD RECORD

Week ending: Dept.:
Machines:
Normal Capacity: hrs. Budget: hrs.

Order No.	Part No.	Hours		Order No.	Part No.	Hours	
		+	−			+	−

Fig. 56. Master Load Record

THE ROUTE CARD AS PROGRESS MECHANISM

The route card may be used in the following manner. The card is made out in triplicate, and two are kept in the office

for recording progress while the other acts as a route tag attached to the back of the drawing.

One card in the progress office is moved, in this case, on a board as operations are done, and the other is filed for quick reference—but both carry all detail of work done.

This method is not very satisfactory, and the choice of a progress mechanism is usually a copy of the job note or ticket.

THE JOB NOTE AS PROGRESS MECHANISM

The job note (Fig. 57) is made out in duplicate form from

JOB NOTE

Op'n.: 23. LEB 1/1	
Station: I.X.	Date Wanted:
Machine:	Drg.: LEB. 1.
Set-up Sheet No.: LEB. 1/1.	
No. Off: 500	Time: 26 hrs.

FIG. 57. JOB NOTE

the route card, and both copies of the note carry the date when the job should start; this date may be approximated from the general schedule or may be specific from the sequential load. One copy of the job note is filed under order number, the other under operation in date order.

The day before the time of starting the job a check up of stores material is made, and, if this is correct, the notes are both moved to a rack (Fig. 58), under "jobs not yet at machines," a material release note going to stores (see Fig. 31, page 110). From there they are moved up to "next job (at machine)" in the same rack, and, finally, one copy goes to the operator and the other remains at "job in work" in the rack. When the operation is finished, a move ticket (see

Fig. 32, page 110) is used to move the job to the next operation or to inspection. In the first case the operation job ticket is sent on to costs and the other destroyed after

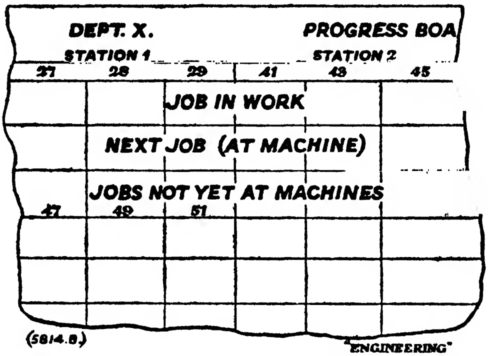


FIG. 58. PROGRESS RACK

the route card is marked up; in the second case the operator's job note is sent to inspection and the progress copy is filed under job at inspection.

THE PARTS LIST AS MASTER RECORD

In general engineering work the parts list (Fig. 59) is the

PARTS LIST AND SCHEDULE

Order No.: Description:
Assembly Drg.: Date Issued: Date Wanted:

Part No.	Name	Mat'l	No. Off	Drg.	St'k or Sp'l	Operations and Dates							
						1	2	3	4	5	6	7	8

FIG. 59. PARTS LIST AND SCHEDULE

most economical record of the movement of the parts of a non-stock job. To use it for this purpose it will be necessary either to add a date column or to attach a slip with a date column printed on it. As each part is completed the date of completion is marked on the parts list; as already

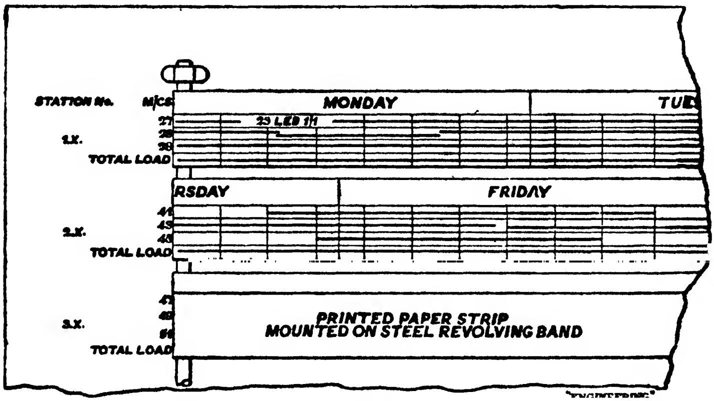


FIG. 60. SEQUENTIAL LOAD BOARD

noted (pages 117 and 198), products parts from stock are reserved—such parts are progressed independently.

The use of the parts list for this purpose avoids the common fault of machines at the assembly stage being short of one or two odd parts.

FULL PLANNING

The full planning technique schedules every operation and records the progress of every part at every operation. For this a planning board is generally used (see Fig. 60). An outline of the full planning technique is obtained by considering this illustration in conjunction with Figs. 54, 57, and 58.

The full technique is for the stock and continuous production shop, and, in these shops, is fairly easy to install and run. For the majority of engineering shops it is, as we have stated earlier, not very applicable.

THE PROGRESS BOOTH

In the majority of engineering works it is best to keep the progress rack in a booth occupied by a clerk whose function it is to sort out and rack the job notes, control the work movement, and clock operation times. Job notes are usually made out in a central department.

In the small shop (about 100 people) the progress rack may be in the manager's office; where there is only one foreman in each of the machine, fitting, and other shops, the racks may be kept in the foreman's office and be operated by youths. In the large shop it may be necessary to have more than one booth.

Job notes are released to the progress booth with the type of machine to do each operation noted; only when the booth clerk starts to fill up his rack does he add the machine number. This is flexible as distinct from inflexible planning. The booth clerk also releases material from stores (see Fig. 31, page 110), and is responsible for moving work (see Fig. 32, page 110); a copy of the route card (Fig. 55) is his reference point for progressing.

PLANNING ROUTINE SIMPLIFICATION

Too often the engineering executive is convinced by high-pressure salesmen that one or other method of producing route cards, job, and other notes is a planning system, when, in fact, such methods may worsen rather than better the works position. Such methods are not planning systems but are aids to quick, accurate production of necessary forms. Nor are the expensive boards and coloured bead and tab systems any more than tools used by the planner.

On the other hand, any method which will truly simplify planning routine is worthy of consideration. One such method[1] mechanically produces all job notes, material notes,

[1] The Ormig Simplex.

progress slips, and cost cards from a typed master route card and is worthy of consideration by all but small engineering companies. The method may be applied at the parts list stage to originate all instructions covering material reservations and requisitions mechanically.

An interesting development[1] is one which attempts to obviate the delays between work being done and receipts of information by the central control office. A system of dialling is used in the works to transmit to a central control office information about material released from and received in stores, jobs started, held up and finished—the operators themselves do the dialling. This method has much to commend it.

COST OF PLANNING

Typical costs of planning and progressing, including making out route cards and job notes, are as follows—

150-*Employee Shop*: One man, one lad, one girl. In this shop the material control records are kept by this staff.

250-*Employee Shop*: Two men, one lad, one girl. Here also material control records (except general stores) are kept, and the girl types works letters. An errand boy runs errands and makes teas when he can be found.

900-*Employee Shop*: Three men, one lad, and three girls. They handle all planning (not process) and progressing and material control.

[1] The Temporator.

CHAPTER XXI

HUMAN EFFECTIVENESS

It is a poor book on management and organization which has not a variety of welfare, square deal, and like expressions of industrial humanistics to leaven the strident note which dominates most such books: "How to cut your costs (safely)." This book is a frank treatment on how to cut costs, and, even in this chapter, we will only for a moment escape from cost cutting objectives. Elsewhere the writer has said his say on industrial scientifics and soporifics,[1] and will keep largely to the cold-blooded angle of how to cut costs (safely), rather than meander fashionably in the realms of sociological, anthropological, and psychological aspects of industrial group effort.

SUBJECTIVE ANALYSIS

The face-to-face analysis of motives and feelings in work is one about which we cannot say much. The writer, however, has been called upon to make such analyses among managing and operating groups, and, when in contact with large companies, has made it an essential part of the analytical technique with, in most instances, extraordinary results.

In Chapter II a management relations chart is illustrated; Fig. 61 illustrates very baldly the relations of a managing-skilled operator group in a well-organized company complete with modern personnel techniques, vocational selection, canteens, football teams, and works committees.

Much is yet to be done in the matter of observation of management-operator relationships, and the writer suggests that such observation if carried out, say, once each

[1] *Principles of Rational Industrial Management.*

year by the higher management in co-operation with the managing group generally, will do much good. Where this has been done the results have been illuminating, and, in all

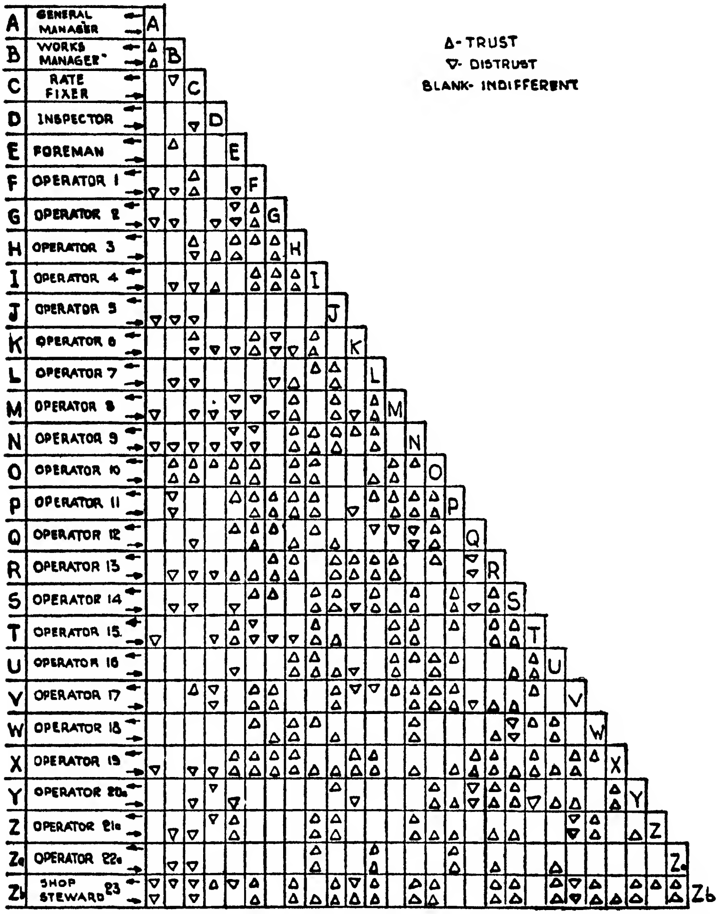


FIG. 61. MANAGING-OPERATOR GROUP RELATIONS CHART IN A LARGE COMPANY

cases, have proved that the lower management groups and the operating groups have little or no real appreciation of company policy. There we must leave the matter meantime.

OBJECTIVE ANALYSIS

The major part of this book has to do with analysis of effort effectiveness, and it remains here only to mention a technique used quite well on work which is mainly non-mechanical.

One can accept a certain figure as representing normal, non-bonus incentive effort and, in terms of this, rate the effectiveness of operator effort. Taking this as a 60 (see page 175), the following represented the effectiveness level of various departments in a representative engineering company—

General office	60	55	45
Typing	75	65	58
Drawing office	65	62	60
Sales department	50	48	40
Maintenance	40	35	35
Estimating	55	55	60
Dispatch	45	35	50
Tool-room	60	55	45
Fitting shop	65	60	55
Machine shop	70	65	60
Machine moulding	75	72	—
Bench moulding	75	70	—
Floor moulding	65	55	—
Pattern shop	60	58	58
Core shop	70	62	—

Note that these are not figures of job effectiveness but only of operator speed and effort *while work was being done.* The first column is a rating while *work was actually being done*, the second shows the effect of waste time in the morning, before and after lunch, before stopping and, generally, for a full day. The third is for a Saturday morning. The figures are very rough and should be taken as of general merit only.

EMPLOYMENT FUNCTION

In the smaller business the function of recruiting labour is free from the complexities present in a business having,

say, 1000 or more people. In the latter we find job specifications, intelligence and vocational tests, employment forms, and employee records being used, but, on the whole, we cannot therefore say that people in big businesses are more happy, more skilled, or work harder than in small businesses. There is more in the matter than interviewing and testing applicants; the problem may be, and is in some instances known to the writer, one of getting people even to apply for employment, then to start work, then to stay at work.

But given a decent business with decent management and conditions, there is no doubt that an employment technique which tries to get the right kind of person to suit the known requirements of each job in the place is better than method based on, perhaps, the whims and fancies of individual executive officials.

JOB SPECIFICATIONS AND TESTS

In the smaller works the foreman may know all of the facts about a particular job and the kind of person required to do it. In the larger works, where the employment function is separate from the operating function, the facts about each job and about the kind of person needed to do the job are put on paper and are called "job specifications."

The job specification covers in writing the physical aspects of a job (as heavy, light, etc.), experience necessary, skill factors, education and experience required to do the job, tests to be made of the applicant, and payment factors.

Along with job specification go requisitions for employees made by department heads on the employment department and formal application blanks to be filled up by applicants.

There is much to be said for intelligence testing of young applicants and for work and skill tests of older applicants, and the use of either or both will help keep the costs of labour turnover down, if shop conditions are good. Vocational testing, or the testing of particular skills, is not so directly

useful, although the testing of such faculties as spatial perception and co-ordination of hand and eye may prove helpful.

WAGE SYSTEMS

When one considers the numerous wage plans in existence (Rowan, Halsey, Emerson, Gantt, Wennerland, 100 per cent bonus, daywork, measured daywork, and others) there does not appear to be any very grave reasons for departing from the simple plan of daywork rate plus straight non-sharing bonus; i.e. the system of setting times on work and paying the operator his base rate for the time he saves on the time set.

The chief factor responsible for the arrangement in such systems as Rowan, Halsey and the like sharing the savings was uncertainty in rate-setting, but rates may now be more accurately set than in the past. In the pattern shop, however, there is something to be said for the 50-50 sharing of bonus plan if day rate is to be departed from.

Yet the problem of whether or not the operator who consistently reaches, say, 30 per cent bonus is worth more than twice the bonus of the operator who earns only 15 per cent remains. Nevertheless, the well-proved system of straight bonus seems generally satisfactory to management and to operators.

Straight Bonus. This method is already popular in engineering works, and little need here be said about it. It is simple in all its aspects, but it does require fairly accurate rate-setting—a factor sometimes missing. It requires, also, to be successfully worked, that the maximum possible service be given operators so that they will take full advantage of the bonus earning potentialities in the rates set.

It is not sufficient to set a rate, then be content if operators make 10 instead of 30 per cent, for, with the increasing tendency for the overhead to direct worker hour rates to

increase in industry, it is of prime importance that the rate of production of the operator be up to a reasonable standard.

Group Bonus. While the 100 per cent bonus system appears to be most suitable for the general run of engineering shops, in one-product shops and in heavy general fitting shops the group bonus method may be suitable. As we are not much concerned with motor car factories we may leave these out of consideration.

In departments where there are jobs requiring now one and now two or more operators it may be worth considering a gang bonus system. A gang of, say, five to ten men may be formed who share in the bonus earned on all jobs done by them. One big advantage of this method is that if one member of the group be treated as a leader (by *the gang* as well as by the management) it eases the management task and begets more and better output.

Measured Daywork. Measured daywork of a reasonable kind is a system worth serious consideration in, at least, engineering works on variable, high quality work.

In the schemes of measured daywork with which the writer has been associated, job rates are set as in the 100 per cent bonus plan but the flat rate, plus average weekly bonus for the past three months, is paid for the following three months. The bonus is averaged each week on a moving average basis, and the position of the operator's bonus line at the end of three months determines his rate for the next three months, subject to the ruling of the management. In the determination of the measured day rate such factors as quality of output, willingness to work overtime, and time-keeping have an effect.

The writer favours flat day rate in principle, but, in practice, inclines towards measured daywork as a good incentive method which has stability factors in it not present in other schemes; on high quality work it is especially good.

The effects of measured daywork as observed by the writer

are superior to those of other systems. It gives the operator a chance to get over bad spots; it develops a high rate complex which pride, if nothing else, fosters; it removes much of the friction from rate-setting, and it stabilizes effort. Where it is in use, moreover, the operators prefer it to other schemes.

STAFF PAYMENT

While the payment of less responsible grades of staff does not present many problems as to salary base, the payment of the higher grade of staff presents the observer with many contradictions. Such salaries are sometimes based on "what we have always paid" and "what we now pay Mr. X" considerations, or, perhaps more common still, on a "what we can afford" outlook.

The various bases mentioned above as determinants of higher staff salaries may, on occasion, get and keep men suitable for higher posts, but, in the writer's experience of over four score companies, they do not always so act. When they do so act, the result is that good men are underpaid and know it, with poor results.

The job and its potentialities should be considered and the salary offered should cover the job needs. The payment of a head draughtsman £400 per annum in a *general* engineering company on good-class products the turnover of which is about £200,000 each year is just silly, as is the paying of a works and production manager £500 on the same basis, and the paying of a general manager £800. If, in general, these men are worth only that, then the sooner new men are employed the better for the company. Actually, 25 per cent more looks more reasonable. With a £1,000,000 turnover, these latter figures could be doubled (for the right men) and not too much would be paid. We should pay not alone what the job affords, but what it *will* afford if rightly run.

CHAPTER XXII

ESTIMATING

ESTIMATING in the engineering company meeting the market with both standard and special products is not the mere arithmetical matter one is led by various writings to believe it is. In short, it is mathematical calculation modified by shop experience and, ultimately, by knowledge of the market.

As we are concerned more with estimating methods and angles than with estimating costs we may forgo the purely analytical approach.

ESTIMATING AND COSTS

The writer knows one concern which was convinced by an organizing company that its costs and estimating ought to be "more closely co-ordinated," so costs and estimating were put under one head; the result was that in six months profits became losses and a change back was made to part-rule-of-thumb method, and with it went all the pretty forms previously drawn up.

Yet another company changed estimating over from being under sales to being under the technical department. Much the same result took place as in the previously quoted case.

Manufacturing cost is only one factor in price, and while cost should closely be considered, market factors should receive full consideration.

IMPORTANCE OF RIGHT CONTROL

In the company meeting a competitive market on special work (or, indeed, on standard work) the most important factor in estimating is the man who controls it. True, this may sound unscientific and "rule-of-thumbish," but,

whether that is so or not, it is cold fact. Accurate costing and estimates broken down to the minutest operation are not nearly so essential as sound works and sales experience in the estimating controller.

In general the writer favours estimating being under or with sales, or, at least, favours the sales manager having a final say in price offering. This is true especially of the company which is selling more than labour plus material plus overheads plus profit, and has good reputation, good design (good thinking), and a name for service. A score of companies could be named which make that extra 5–10 per cent on price when selling to customers who, the estimating controller knows, will pay extra for these imponderables.

ESTIMATING TECHNIQUE

Keeping in mind what has already been said in this chapter, we must agree that estimating should at once be a reasonable reflection of works costs and a powerful factor in works future costs.

With regard to the first of these factors, the reflection of works costs, it is suggested that accurate costing is essential to good estimating. It is not, however, suggested that estimating need always result from a complete forecast of cost part by part and operation by operation. Where this is possible and economical, all the better for the company, but, in practice, it is not always possible.

On the other hand, "wild guesstimating" is of little value and there should be a building up of preceding part costs and sub-assemblies to guide the estimator. This can easily be had if operation costing is the rule.

Further, estimates should certainly be broken down to, at least, major sub-assemblies when there are sub-assemblies, and works departmental direct labour costs should be shown, as should drawing office probable cost, material, overheads, erection cost, if any, and carriage. This will provide a fair

basis for estimate-cost comparison and will lend itself to pre-costing.

Obviously, estimating should not be done on "bits of plain paper" but should be done on standard forms, of which the cost department gets copies.

ESTIMATE AS PRE-COST

Many more companies than do so could effectively use the estimate as a basis for pre-costing. The technique is comparatively simple, and, while we cannot here explain it in minute detail, the following will suffice to start a try-out where a try-out is reasonable.

The direct labour costs shown in the estimate (shown under sub-assemblies and departmentally) are kept by the costs departments. The ratefixing department is requested by the cost office to return records of all rates on any sub-assembly before the jobs go into the shops. The rates return is compared with the estimate, and, if the return is higher, a conference to promote suitable action takes place. Then, and only then, are rates issued to the shops.

On standard work, cost variation control is fairly simple; for work varying from standard it is generally worth reorganizing both costing and estimating method to attain the method outlined above.

COST OF ESTIMATING

About one estimator per £75,000 turnover, with more than half non-standard, seems general. A company having £1,000,000 turnover on 25 lines, three of them stock, 10 per cent inquiries turned to sales, has 11 estimators. A company with six lines, three stock, has four estimators with a £400,000 turnover. Another company with 21 lines, mostly standard, has one estimator with a turnover of £125,000. No average can be given here because the average contains too many divergent factors.

CHAPTER XXIII

COSTING

THE function of financial accounting is to record and measure all the financial transactions arising in the course of running a business. Cost accounting, on the other hand, has for function the application of financial accounts data to the product for the purpose of arriving at the cost of the product.

We do not need here to wander through the academic labyrinths of costing methods and will consider only what method, for general engineering and for variably designed product production, will give the cost of the product.

COSTING EFFECTIVENESS ANALYSIS

The primary trouble with many engineering company cost methods is not, as one would believe from published writings, that the method of overhead allocation and recovery is wrong, but that elementary collection of direct costs is weak.

On more than one occasion the writer has contacted companies having cost systems which were academically the last word but, in practice, failed to unearth cogent production facts having to do with direct material excess use, scrap, replacements, extra labour time because of lack of inspection or design mistakes, and direct labour cost variations generally. True, there are plenty of companies whose cost methods as a whole are open to question, but these are often to be preferred to those which are smugly perfect on paper but blindly weak in practice.

1. Is direct material control so organized that reasonable accounting for all the material in any product takes place? This refers to physical protection of stores, as well as to accurate issue and receipt of material and the allocation in

the accounts of material to jobs. But see Chapters XII and XIV.

2. Is the method of booking direct labour time so reasonably accurate that there is no passing of time from one job to another to earn bonus, and that excess times because of machine break-down, faulty raw material, poor work on previous operations, drawing and design mistakes, waiting for work, and like causes can be collected and accounted for at short periods?

3. Is the storage, requisitioning for, and accounting for indirect material of a major nature such that departmental allocation of such material is reasonably accurate?

4. Given there are heavy and light machines and differently equipped departments in the shop, and that all products do not go through the same processes, is the method of overhead allocation such that each product or each size of product is charged with the overheads it incurs in the shops?

5. Is the company content only to run out total fitting, machine, plating, and other department costs in the cost ledger? If so, what control is there of operation cost and, on similar or nearly similar work, of operation cost variations?

6. Given that the estimates on special work are reasonably broken down into, at least, fitting, machine, and other departmental costs, is any attempt made to ensure in advance that the control times put on to operations fall within the framework of the estimate? (Pre-costing.)

7. Is any attempt made, either by linking cost with financial accounts in the cost ledger or by periodical check, to compare overheads recovered in the job accounts and overheads naturally incurred in the running of the business?

Here we have touched on the major aspects of cost method, and may, for the moment, leave minor matters of cost office organization and costing simplification machinery on one side.

OVERHEAD RECOVERY METHODS

In the engineering trades generally, and in this we include companies having 50–250 people as well as larger companies, the most usual method of overhead recovery is by percenting total overhead expense (indirect labour, indirect material, management, depreciation, rents, rates, taxes, power, etc.) to direct labour. Direct labour and direct material can accurately be booked to specific products, and other expense, reasonably enough, is ratiod to measurable factors. But, for a company having different type and designs of products requiring different processes, is it enough to use a blanket method of overhead recovery?

To put it another way, by recovering depreciation, power, rents, rates and taxes, for example, as a percentage on direct labour, does each product carry the overheads it incurs? If some products require a heavy planer, borer, grinder, gear cutter, or lathe, while others require none of these but only light machines, it is obvious that the overheads incurred in one hour by the first class of product will be different from those incurred by the second.

Recovering overheads as a charge on direct labour hours avoids the fallacy of low charges against jobs done by cheaper labour on expensive machines, but it does not distribute overheads rightly in the kind of shop with which we are dealing. So too is collection and recovery of overheads by departments on a direct labour wage or time basis better than the blanket method in a general machine shop, but this does not give us true costs.

Thus, it is reasonable to suggest that such overheads as vary in proportion with direct labour time or wage should be recovered on direct labour time or wage, but those which vary directly with other factors, machine hours, wages direct plus factory overheads, and selling price, or even with quantity in an order, should be recovered in proportion to these factors.

DEPARTMENTAL OVERHEAD ALLOCATION

If there are various departments and some products go through some departments and others take a different route, then, in the first place, overheads should be listed to discover which can truly and usefully be allocated to departments.

The basis of overhead allocation to departments will probably be as follows—

Rents and rates, building repairs, and fire insurance	Floor space basis.
Heating	Number of radiators.
Depreciation	Actual.
Plant repairs	Actual.
National insurances	Actual.
Power	Actual.
Lighting	Points in department.
Foremen	Actual.
Labourers	Actual.
Manager's salary	Men in department.
Materials such as Weld rods, oxygen	Weld shop.
Materials such as Compound pots	Casehardening.
Small tools	Actual.

Fig. 62 illustrates an overhead distribution form.

MACHINE OVERHEAD ALLOCATION

In a general machine shop through which pass different products or even one product varying from light to heavy (as light and heavy tools, motors, gears, etc.) it will be necessary to apportion at least some overheads on a machine-hour basis. Depreciation, power, rents, rates, taxes, and repairs are the chief of these.

All machines should be listed and the charges worked out for each on a normal utilization basis (see under). Obviously, the charges as apportioned should be abstracted from total overheads.

In the small engineering works it may be necessary only to apportion depreciation, power, and rent, rates and taxes (on a floor space basis), and to recover other overheads

OVERHEAD DISTRIBUTION FORM

	Light M/c Shop		Heavy M/c Shop		Fitting Shop		Plating Shop		Weld Shop		Pattern Shop		Foundry	
	Floor Space	% of Total	Floor Space	% of Total	Floor Space	% of Total	Floor Space	% of Total	Floor Space	% of Total	Floor Space	% of Total	Floor Space	% of Total
Total floor space														
Total overhead = £	Value £	% of Total	£	% of Total	£	% of Total	£	% of Total	£	% of Total	£	% of Total	£	% of Total
1. Rent														
2. Rates														
3. Taxes														
4. Building repairs														
5. Fire insurance														
6. Building department														
7. Plant department														
8. Plant repairs														
9. Power														
10. Light														
11. Heat														
12. Labourers														
13. Chargehands														
14. Foremen														
15. Small tools														
16. Sand														
17. Supplies														

FIG. 62. OVERHEAD DISTRIBUTION FORM

(except selling expense) on a blanket basis. The larger company may apportion, also, repairs, light, heat, and tools on a machine-hour basis. Where machines are somewhat similar in age, first cost, and power requirements, a machine centre hour rate for these machines may be used.

WELDING, PLATING, CASEHARDENING, AND FORGE OVERHEADS

While a machine-hour rate is necessary for a machine shop, a general departmental charge is usually good enough for the fitting shop. For other shops this may not, however, be so suitable.

The casehardening department can usually be quite effectively covered by a total cost per pound of metal hardened, this including hardening compound, labour, and departmental overhead. It is a mistake, however, to group small and large work, thin and thick sections under one cost—class costs should be used.

The plating shop on templating, burning, planing, drilling, riveting and assembly work is best departmentalized; where a variety of light and heavy work is done, it is worth considering the use of machine rates. If punching is used on some work and drilling on others a machine rate will be likely to be necessary.

If the plating shop includes a welding shop and everything is welded (not riveted), one departmental will be fairly satisfactory in the shop of less than about 30 people. If both riveting and welding are used, welding should be departmentalized. In the large shop, templating, welding, drilling, and riveting will be departmentalized.

A welding shop attached to an engineering shop should be departmentalized for the purpose of factory overhead recovery.

A forge, or even a blacksmith's shop on production work should be departmentalized for costing purposes. If a

variety of work goes through a production forge, and hand anvil, mechanical anvil, large and small power hammers, and forging and hot stamping machines are used, it will be worth considering the use of machine rates.

THE PATTERN SHOP

A serious fault against which the writer often stumbles is that of charging the pattern shop as a whole against the engineering side of the business.

The pattern shop in nearly all cases should be departmentalized for costing purposes, and direct wages should be kept separate from checking, labouring, and management and general overhead expense. Direct labour times should be logged, and all new patterns should carry their own overhead and be charged to specific jobs; so with major pattern alterations. Other overheads can be charged in ratio to the value or tonnage of castings in the product.

The last suggestion is somewhat revolutionary—but it works well.

THE JOINERS' SHOP

Often one finds a joiners' shop engaged in making product parts (e.g. lift cages), dispatch cases, and odds and ends for the works and offices inside or alongside the pattern shop and charged in with the pattern shop.

The joiners' shop should, for costing purposes, be departmentalized, work done should be logged, and time should be charged to the order in the case of dispatch boxes, to repairs in the case of repairs, and to furniture when cabinets and the like are made for internal use.

As with the joiners' shop so should other departments on production work be treated departmentally when *all* production work does not go through them, or the products vary widely in their demands on the departments; when such demands do not vary directly with direct labour wages,

they should be measured in terms of direct labour hours or on some other basis which is reasonable.

DIRECT MATERIAL AND LABOUR ACCOUNTING

The various requisitions and forms used as the basis for direct material accounting have fully been dealt with in Chapter XII.

Direct labour will be accounted for through the medium of job notes or tickets, and the method of handling these into the job accounts will be dealt with in a later chapter.

At this point it is as well to suggest to small companies that if costs are to be accurate and cost variations are to be controlled, then the most reasonable method of meeting these needs is by the use of operation job notes where feasible. Quite recently, the writer has come across companies having 100–200 people who use the "table tennis bat and chalk" method of booking direct labour time or, not much better, daily log sheets filled up by the operators.

NORMAL AND ABNORMAL OVERHEADS

It cannot too strongly be insisted that the overheads which a company aims to recover be the overheads normal to a normal year of business. Too often, one finds a company calculating overheads on "last year's working" when, in fact, last year may have been abnormally good or bad.

True, overheads need recalculation during and after reorganization (owing to reduction in direct labour cost usually) and when changes in production plant and buildings or in major salary policy take place; otherwise they should logically remain the same.

Profits and losses can be made on overhead recovery above and below normal, and a good cost accounting system will effectively cover this important point. How it is covered is dealt with in the next chapter.

CHAPTER XXIV

COST ACCOUNTING SYSTEM FOR A COMPANY HAVING ABOUT 500 PEOPLE

It is unfortunate that very few multi-product engineering companies have an adequate system of cost accounting. True, they often have an effective method of overhead allocation, and, unfortunately, the difference between good overhead allocation and good cost accounting is not very clear.

DOUBLE-ENTRY COST ACCOUNTING

The method outlined hereunder does not fully tie up the financial books of accounts with the costs accounts, though it goes far enough to ensure accurate cost accounting, and, mark this, it does not and cannot ensure that overheads are properly allocated, that material control will give accurate returns, that labour effort will be measured accurately into work done, nor, in short, that the works are efficient. Given, however, a certain standard of operating effectiveness, be it good or bad, right cost accounting will help in controlling variations from that standard.

Double entry simply means that every entry on, say, the *debit* side of one account must have a corresponding entry on the *credit* side of another account; the account which gives is credited and the account which receives is debited. Thus, if stores give £100 of material to a job, Stores Account is credited (as it gives) and the Job Account is debited (as it receives).

ACCOUNTING RECORDS

The books and records kept will depend on the size of the company and on its products. In practice, the following are usually sufficient—

Cost Control Ledger

Job Ledger
Stock Ledger.

Such books as Stores Inward Book, Stores Issue Book, and Material Transfer Book will be unnecessary if requisition invoices and like dockets have their values posted into the Stock Ledger.

The Cost Control Ledger (it may be loose-leaf or card) contains total accounts for each of the other ledgers.

It is only with impersonal accounts that the Cost Ledger accounts are concerned; accounts for debtors and creditors already exist in the general financial books. There must, however, be some kind of account in the Cost Ledger to take the place of the personal accounts in order that double entry may be complete. This account is the Cost Ledger Control Account.

When a supplier gives, the Cost Ledger Control Account is credited (for it represents the supplier's account) and the account which receives is debited. When a customer receives, the account which gives is credited and the Cost Ledger Control Account is debited (for it represents the customer's account).

The Job Ledger shows an account for each job. Jobs when small and not requiring many postings are best in card form, and these job cost cards are the Job Ledger (see page 227). Direct wages are posted to the Job Accounts from the job tickets through a Wages Abstract (Fig. 63). Direct material is booked to the Job Accounts through a Material Abstract (Fig. 64) from material cards (see page 111) or from requisitions.

The Stock Ledger may be the balance-of-stores records in total (see page 108). In the Cost Ledger a Stores Ledger Control Account will be opened and all debit and credit items in the Stores Ledger are posted in total to this account.

Stores material bought is posted from suppliers' invoices or from an analysed Purchases Day Book; material issued

WAGES ABSTRACT

Man's No.	Job No.	Job No.	Job No.	Job No.	Job No.	Job No.	Job No.	Job No.	Job No.

FIG. 63

MATERIAL ABSTRACT

Reg'n Code	Job No.	Job No.	Job No.	Job No.	Job No.	Job No.	Job No.	Job No.	Job No

FIG. 64

to production from material cards or from requisitions; material returned from production to stores from shop credit notes; material returned to suppliers from analysis of suppliers' credit notes. The totals of the foregoing and of other material transactions will be entered at the end of each cost period in the Stores Ledger Control Account.

A DETAILED STATEMENT OF NECESSARY COST ACCOUNTS

The full advantages of double-entry cost accounting can be seen by an outline of the working of the method *for one period* of, say, four weeks.

To explain the difficulties likely to be met we have taken

five jobs, of which three have been delivered (1, 2, and 3), one is part finished (4), and one has been partly delivered (5).

JOB LEDGER CARD

Order No.: 1 Description:

Pre-cost: Customer:

Dr. *Cr.*

Material	Labour	Works Oncost	Total	To Job Summary
£ 400	£ 100	£ 120	£ 620	£ 620

JOB LEDGER CARD

Order No.: 2 Description:

Pre-cost: Customer:

Dr. *Cr.*

Material	Labour	Works Oncost	Total	To Job Summary
£ 200	£ 80	£ 140	£ 420	£ 420

JOB LEDGER CARD

Order No.: 3 Description:

Pre-cost: Customer:

Dr. *Cr.*

Material	Labour	Works Oncost	Total	To Job Summary
£ 1000	£ 250	£ 300	£ 1550	£ 1550

JOB LEDGER CARD

Order No.: 4 Description:
Pre-cost: Customer:
Dr. *Cr.*

Material	Labour	Works Oncost	Total	To Job Summary
£ 800	£ 150	£ 200	£ 1150	£ —

JOB LEDGER CARD

Order No.: 5 Description:
Pre-cost: Customer:
Dr. *Cr.*

Material	Labour	Works Oncost	Total	To Job Summary
£ 50	£ 20	£ 25	£ 95	£ 63
		Balance	32	Balance 32

Nos. 1, 2, and 3 we transfer to the Job Summary and add office and selling charges; No. 4 we do not so transfer as it is incomplete, and No. 5 we calculate for value delivered but take no profit. The Job Summary then stands—

JOB SUMMARY

Job No.	Works Cost	Office Abstract	Selling Oncost	Sales Value	Profit	Loss
	£	£	£	£	£	£
1.	620	60	85	950	185	—
2.	420	40	50	610	100	—
3.	1550	100	150	1775	—	25
4.	—	—	—	—	—	—
5.	63	5	7	75	—	—
	2653	205	292	3410	285	25

Now, it is necessary to keep a Work in Progress Account which will give us the value of work in progress; this is a control account and is kept in the Cost Ledger. The account has transferred to it total direct labour for the period from the Wages Abstract, total material issues from Material Abstract, and works oncost from an Oncost Abstract. The Work in Progress Account would then be as follows—

Dr. WORK IN PROGRESS ACCOUNT *Cr.*

	£		£
To Labour . . .	600	By Transfer to Cost of Sales	2653
,, Materials . . .	2450	,, Balance c/d . .	1182
,, Works Oncost . .	785		
	£3835		£3835
To Balance b/d . .	1182		

The balance of the Work in Progress Accounts represents the works cost of Job No. 4 not completed, and Job No. 5 on which £95 in works cost has been spent during the period but goods delivered have been estimated to have cost £63, leaving a balance of £32. Thus, £32 plus £1150 (Job No. 4) = £1182 = balance of Work in Progress.

Our next account in the Cost Ledger is the Cost of Sales Account, to which we transfer the total works cost of sales, add to it office and sales oncost recovered, and then subtract these from the value of sales (all from the Job Summary).

Dr. COST OF SALES ACCOUNT *Cr.*

	£		£
To Transfer from W. in P.	2653	By Sales	3410
,, Office Oncost . .	205		
,, Selling Oncost . .	292		
,, Profit to P. & L. a/c .	260		
	£3410		£3410

Note that the value of all work not delivered is kept in the Work in Progress Account until delivery takes place, when the values are transferred to the Cost of Sales Account.

Before going further it is necessary for us to compare actual overheads with those recovered. This we do in overhead or oncost accounts in the Cost Ledger—

Dr. WORKS ONCOST ACCOUNT *Cr.*

	£		£
To Actual Overheads .	885	By Recovered	785
		,, Loss	100
	£885		£885

Dr. OFFICE ONCOST ACCOUNT *Cr.*

	£		£
To Actual Overheads .	275	By Recovered . . .	205
		,, Balance c/d . .	60
		,, Loss	10
	£275		£275
To Balance b/d . .	60		

Dr. SELLING ONCOST ACCOUNT *Cr.*

	£		£
To Actual Overheads .	287	By Recovered . . .	292
,, Profit . . .	5		
	£292		£292

The £60 shown in the Office Oncost Account represents oncost accrued on jobs not completed; this is the result of calculation. Selling oncost is not usually applied until the job is delivered.

The Profit and Loss Account, corrected for under- or over-recovery of overheads, will now be as follows—

Dr. PROFIT AND LOSS ACCOUNT *Cr.*

	£		£
To Loss on Works Overheads	100	By Profit on Manufacturing	260
„ Loss on Office Overheads	10	„ Profit on Selling Overheads . . .	5
„ Net Profit . . .	155		
	£265		£265

It will be noted that the profit shown in the Job Summary (page 228) has dropped by about 40 per cent.

At this point it will be necessary for us to consider how we should have treated material, of which we have issued to the works (see Job Ledger Accounts, pages 227–8), £2450 worth. For this sum we have debited the Work in Progress Account (page 229), so, in accordance with the double-entry principle, an account must be credited. This account is the Stores Ledger Control Account in the Cost Ledger.

Suppose, now, we started off with a stores balance of £5000, purchased £3000, issued £2450, and returned to suppliers £80. The account would be as follows—

Dr. STORES LEDGER CONTROL ACCOUNT *Cr.*

	£		£
To Balance . . .	5000	By Issues . . .	2450
„ Purchases . . .	3000	„ Returns . . .	80
		„ Balance . . .	5470
	£8000		£8000

Purchases (£3000) are credited in the Cost Ledger Control Account, and returns (£80) are debited in the Cost Ledger Control Account. Note that what are personal accounts in the financial books are represented in the Cost Control Account in the Cost Ledger.

The Cost Ledger Control Account will now be as follows—

Dr. COST LEDGER CONTROL ACCOUNT *Cr.*

	£			£
To Returns to Suppliers .	80	By Balance . . .		5000
,, Sales	3410	,, Labour . . .		600
		,, Works Overhead .		885
		,, Office Overhead . .		275
		,, Selling Overhead. .		287
To Balance c/d . .	6557	,, Purchases . . .		3000
	10,047			10,047
		By Balance b/d—	£	
		Work in Progress	1182	
		Office Oncost (Suspense) .	60	
		Stock . .	5470	
			6712	
		Profit . .	155	
				6557

The Cost Ledger Control Account serves a useful purpose in that it provides a check on the accuracy of the balances of the other accounts in the Cost Ledger. The balances are analysed in the Control Account shown.

COMMENTS ON ACCOUNTS ILLUSTRATED

In a works making more than one product there will be a Work in Progress Account and a Cost of Sales Account for each product. It is further suggested that the Wages Abstract of page 226 can profitably be laid out to show recovery of fixed as distinct from variable overhead, and that under-recovery of variable overhead be analysed as shown in a later chapter by the use of a flexible budget. For a fairly complete tie-up with pre-costs (for special work) and standard costs (on standard work) the Wages Abstract could be shown as table on page 233.

If overheads be recovered on the pre-cost as well as on actual cost, and variations in direct labour cost and in

WAGES ABSTRACT

Men	Job Number				Job Number				Job Number	
	Pre-cost	Cost	Overheads		Pre-cost	Cost	Overheads		Pre-cost	Cost
			Fixed	Var.			Fixed	Var.		

overhead recovery be worked out and analysed, as near an approach to standard costing as a general engineering company can profitably go will be made.

CHAPTER XXV

COST SYSTEMS FOR COMPANIES HAVING 250 AND 100 PEOPLE RESPECTIVELY

As stated earlier, if even one product is processed through a different department and other products miss that department, then departmentalization for cost purposes should take place. If, again, even one product goes on machines which other products do not go on, and the machines vary as to first cost, depreciation, power, and floor space, then a machine-hour rate should be used unless a product rate can be evolved. This must be done regardless of the size of the company.

DIRECT LABOUR AND DIRECT MATERIAL

Both companies would use operation job tickets and both would use control times or bonus times on all work, excepting, perhaps, on one machine or man engaged on oddments.

Both companies would have separate job cards for rectification, scrap replacement, waiting on work, machine break-downs and the like, and would have the times on these job notes analysed each week and costs got out under each heading.

In one machine shop having 35 operators the use of job cards for the items mentioned in the previous paragraph showed up waste time of 47 hours each week. This was reduced to 8 hours after one week.

Both companies will have adequate control of stores and will release material only on receipt of an authorized form.

LABOUR AND MATERIAL ACCOUNTING IN THE LARGER COMPANY

For the average engineering company having 250 people the writer strongly recommends that route cards be used

and that the operation and part cost records be compared with these. Such a route card is shown in Fig. 50, page 184.

It may be argued that this method means that someone will have to write out a route card for each part; this is quite true of non-repetition parts, but tests show that the advantage of having simple operation planning plus adequate cost records far outweighs the slight extra cost. Yet another advantage is that for future estimating and rate-setting the records are invaluable, and, last but not least, the filing of thousands of job notes (which are seldom referred to) is eliminated.

If a small planning department is operated, two copies of the route card may be made out; as job notes come in these will be passed across the route cards, then, in the case of standard work, be checked for variations, and in that of special work, be entered up. A copy of the standard work route card will be filed in the cost office and variations will be noted thereon; the extra copy of the special work route card will go to the costs department. In two companies the route card goes to the cost office via stores, where material cost is entered up.

On the other hand, all labour and material costing may be done in the costs department; a procedure which may not give such vital control as when, at least, direct labour costing and cost checking is done in the planning department.

LABOUR AND MATERIAL ACCOUNTING IN THE SMALLER COMPANY

Out of fourteen small companies contacted by the writer, only three had parts lists (see Fig. 7, page 43), two used operation job tickets, and none had route cards.

The most general method of costing is based on calculation from figures entered up on boards or on sheets by the operator. Material is costed from the drawings or from requisitions

on poorly controlled material, and overheads are lumped on to direct labour cost.

Even for the smaller company the writer suggests the use of route cards and, by all means, of operation job notes.

Where route cards are not used, material and labour costs may be entered in detail on an extension of the parts list. The list, when completed, will be an excellent record for future estimating and for comparative ratefixing.

OVERHEAD ACCOUNTING

As the cost accounting method mentioned in the last chapter is not here suggested for use it will be necessary for the companies treated in this chapter to use some kind of analysis sheet for the dissection of departmental overheads: indirect labour, material, repairs, power, and like variables. Such items as rents, rates, taxes, management salaries, office expense, and sales expense will be shown in total in the financial books of account, as will more variable factory expense, but if control is to be reasonably adequate, a special sheet will have to be used for entering up this variable factory expense at defined periods under departments.

CHECKING RECOVERED AND INCURRED OVERHEADS

In the previous chapter the checking of overheads incurred against overheads recovered was dealt with through the cost accounting system. Here it cannot be pretended that without such an accounting system we can accurately account for overheads, yet so important is it that some effort should be made to do it. It is not enough to add up all profits and losses in the Job Accounts and imagine these give a true profit position. The writer has newly returned from a company in the North which, on advice, got out a Profit and Loss Account for the preceding three months and showed a mean profit of £2800 against £4700 in the job cost cards.

This difference turned out to be largely one of overhead accounting.

To get out indirect wages and salaries, rents, rates, taxes, and other overheads from the financial books of accounts is not difficult. The real problem is to bring in work in progress. This, however, may be calculated from the route cards, which show all the work done on each item in the shop and on which direct costs plus overheads are entered so that overheads may be abstracted.

The foregoing method is rough and ready, but it will give fair control and will correct inaccuracies in job cost profit and loss results.

PROFIT AND LOSS ACCOUNT AS CHECK

The smaller company will be unable to calculate work in progress value unless the parts cost record is minutely extended. A Profit and Loss Account should be run out as a corrective at, say, three-monthly periods. This will make necessary the taking of stock and of work in progress.

In conclusion, it may seem that to run a proper cost accounting system is more economical than to undertake the manoeuvres mentioned in this chapter. The writer is inclined to think so, but the situation is often such that it is possible only to use a very direct and simple method with correct cost and maximum accuracy as the dual goals.

If neither of the types of companies dealt with in this chapter wish to go to the trouble of getting out work in progress overhead investment, it is essential that short-period Profit and Loss Accounts be used.

COST OF COSTING

With a system as in Chapter XXIV, the worker–cost staff ratio is about 70 : 1; including wages and statistics, 60 : 1. In the modern cost office, the female–male ratio will be about 3 : 1.

CHAPTER XXVI

FINANCIAL AND OPERATING ANALYSIS AND CONTROL

It will have been noticed that although, for example, we know what overheads are incurred and what are recovered in a company (see page 230), and although we may show a profit or a loss on overheads in any period, we do not yet know what the overheads should be for the output shown in any period. To put it another way, we may show a profit in Job Cost Accounts of £250 and in the costing Profit and Loss Account show a loss of £250. The problem is, where exactly is the difference of £500? At this point financial control becomes useful, just as in other matters not defined or controlled by costing it becomes useful.

PURELY FINANCIAL INVESTIGATION OF LIMITED VALUE

It will be as well to make clear the true value of financial analysis, i.e. of analysis of the position of a company through scrutiny of past and present Balance Sheets, Profit and Loss and Manufacturing Accounts, and Cost Accounts.

In short, financial analysis can work only on a comparative basis, and the standard technique of collecting and comparing various financial statements and ratios derived therefrom depends on a best year as base, and the true effectiveness of a company cannot thus be arrived at.

For example, the writer is intimate with many engineering and founding companies whose net and gross profit position, working capital position, and stock and fixed assets position was very sound, yet considerable improvement in the total financial position was made by engineering analysis and reorganization.

Again, a company in a poor way may be put in the hands of financial specialists and either sold or shut down when, in fact, thorough engineering scrutiny may have stabilized it. A recent case comes to mind: an old-established and respected company made increasing losses over a period of six years, and, on the advice of financial specialists, sold out to a larger company. The larger company reorganized the business just bought, and, leaving aside savings from office and administrative centralization, the bought company showed a clear profit on its own operation in nine months.

PURELY FINANCIAL CONTROL OF LIMITED VALUE

The use of working capital, quick position, stock turnover, gross and net profit, and like ratios is of value, but only if the ratios are derived after thorough investigation of business effectiveness, and only if, when such ratios show something wrong, there is a system of basic controls to say where the wrong is.

Two companies of fair size had, in the writer's knowledge, a complete system of financial and operating control ratios; in the first the cost system was sketchy, and when some of the ratios showed poor operation no one could find where the poor operation was; in the second company a good cost system was in operation, ratios were fine, yet general fitting costs were 40 per cent too high owing to poor quality control, and machine shop costs were 22 per cent too high because of lack of simple process planning.

Again, there are numerous companies having fortnightly or monthly Profit and Loss Accounts taken out, yet, so poor is costing, they have little or no idea exactly where losses of profit occur. One such company had an amazing system of laying out financial accounts so that every item of expense could be ratioed to sales, output, or what not, and compared over periods extending back ten years, yet it made losses; not because of lack of basic management

ability, but because the chief executive official had one, and only one, "bee in his bonnet"—higher financial control.

THE BASIS OF EFFECTIVE CONTROL

Given that a non-continuous and non-repetition engineering organization is *normally effective in all of its departments*, the basis of effective control can be stated as follows—

1. A method of costing which accurately records direct labour and material expense in terms of either standard or pre-cost (in the case of standard and special work respectively); which accepts overheads on a *normal* capacity basis and allocates them in such a way that each product is charged with the overhead it incurs; and which continuously draws production executive official attention to prime cost variations and at short periods of, say, four weeks, produces for higher executive official scrutiny a true statement of job profits and losses in single and in total, with explanation of profits and losses on prime cost and on fixed and variable overheads.

2. A simple flexible budget which covers all expenditure other than prime cost expenditure.

3. A simple system of ratios which covers working capital position, stock and work in progress investment position, debtors and creditors, turnover of fixed assets, and gross and net profit.

Given these, or the first two of these plus the most important of (3), general financial control will be quite adequate.

FIXED OR FLEXIBLE BUDGET?

The number of engineering companies which can effectively budget all direct material and labour and all overheads on the basis of known future sales is comparatively few. Yet, quite a number of companies try so to do on the basis of past sales, plus promises from district representatives, plus, in a few instances, the help of business forecasting,

when, in fact, sales variations are almost certain to be such that the fixed budgets of expense become a delusion and a source of worry to those people who have to keep to the budget.

A flexible budget is adjusted to time and activity. Thus, for fixed expense, time is the important factor, while, for variable expense, the amount of activity to which the budget is related is the important factor. The fact that the budget is flexible does not hinder the operation of a sales forecast in total, by lines, and by territories.

THE BASIS OF THE BUDGET

There is a difference of opinion among accountants on whether the basis of the budget should be the average rate at which a factory may be *expected to work* over future years, or the rate at which factory equipment *could operate* if there were plenty of orders. The writer prefers the latter, minus allowance for repairs, shortage of personnel, break-downs, ineffective operation, and other normal delays not caused by lack of orders; generally, the figure works out at about 80 per cent of the normal or effective capacity.

To get out the budget it is necessary to calculate what are the effective hours of operation for the works and for each department for, say, one year. Given this, normal departmental and general works overhead can be distributed as a charge per hour or, although not so accurate as to base, as a percentage on direct labour cost. From this arises the conclusion—

The overhead charged to a product should be that charged at normal volume of activity whether or not volume of activity be normal.

THE FIXED CHARGES BUDGET

To budget for fixed expenses is easy. Thus, superintendents' and foremen's salaries, depreciation, fire insurance,

factory rent, rates and taxes, necessary maintenance of buildings and machinery are fairly well known in advance. Such expense as charge hands' salaries and departmental clerical staff will be treated as fixed or variable according to local circumstances.

Any expense which is not affected by variations in works activity and remains the same whether the plant is operating at any or no capacity is a fixed expense. There are what may be called semi-fixed expenses (e.g. inspectors who are on the staff), but they are a small percentage of total expense and may be treated as fixed.

THE VARIABLE EXPENSES BUDGET

A careful study of past expenses and of probable price levels is necessary for the fixing of variable budget expense; to this usual advice there may be added: and a careful study of past and present expense effectiveness.

Included in variable expense may be: indirect labour and insurance thereon, supplies, power, repairs, maintenance (with the proviso of the previous section), light, and heating.

Much argument may here arise on some of these items placed under variable expense, e.g. that power costs do not decrease per unit of power as power decreases. As, however, this chapter is indicative of policy rather than a definite statement of policy, the reader will solve these argumentative points in the light of local fact.

EXAMPLE OF A BUDGET

If, for example, the practical capacity of a works is put at 200,000 direct hours each year, and on breaking this down to departments we have for the fitting shop 26,000 direct hours, we can separate fixed from variable expense and budget for, say, a four weeks period, then compare actual with budgeted expense as follows—

Fixed Expense	Normal for 26,000 hrs.	For 4 weeks Period, 2000 hrs.	Actual for 4 weeks 2000 hrs.	+ or −
	£	£	£	
Depreciation	182	14	14	—
Rent, etc.	364	28	28	—
Supt. and foremen	390	30	30	—
Clerks	195	15	15	—
Insurance	91	7	7	—
Total fixed	£1222	£94	£94	

Overhead rate for fixed expense £1222 ÷ 26,000 = 11·28d.

Variable Expense	Normal for 26,000 hrs.	For 4 weeks Period, 2000 hrs.	Actual for 4 weeks 2000 hrs.	+ or −
	£	£	£	£
Indirect labour	390	30	33	+ 3
Insurance	63	1	1·3	+ 0·3
Supplies	520	40	44	+ 4
Maintenance	65	5	5·5	+ 0·5
Power	403	21	20	− 1
Light	91	7	8	+ 1
Heat	52	4	4·5	+ 0·5
Total variable	£1584	£108	£116·3	£+8·3

Overhead rate for variable expense £1584 ÷ 26,000 = 14·62d.
Total overhead rate = 11·28d. + 14·62d. = 25·9d.

The foregoing is a simple, hypothetical example which links up with what was previously said about "normal" rates in Chapter XXIII. It is suggested that the reader take actual works activity at 1500 hours for a period, work out under-absorption of fixed charges, and state what variable charges should be.

It should be noted that control of direct labour and material is got through pre-costing (page 215); the budget aims at control of expense and may be extended to office and sales expense.

COSTING AND THE BUDGET

It is obvious that there is a close connexion between costing and this form of budgeting; just how close depends on how near standard costing the business is. Thus, in some works standard costs will be used for direct labour, and standard overhead will be applied to *standard labour cost*, and both labour and overhead variations will be accounted for, as, similarly, will variation in material. In other works, and this includes most engineering works, standard overhead will be put on to *actual* labour cost, and, at the end of each cost period, the total overheads *recovered* will be compared with *actual* overheads (as in the accounting system of Chapter XXIV), and *actual* overheads will be compared with *budgeted* overheads; this will give fair all-round cost control if some form of pre-costing is used.

FINANCIAL RATIOS

If cost accounting is effective and expense is reasonably budgeted on a flexible basis, there is no need for the long list of financial and operating ratios sometimes quoted in publications on financial control. The following effectively cover those items which cannot rightly be covered by cost accounting and the budget—

$$\frac{\text{Cash in Hand and at Bank plus Debtors plus Stock plus Work in Progress plus Investments}}{\text{Creditors plus Bank Overdraft plus Accrued Liabilities}}$$

This is the *working capital* ratio, and for effective operation it should be about 2 to 1.

The *quick position* ratio

$$\frac{\text{Current Assets minus Stock and Work in Progress}}{\text{Current Liabilities}}$$

is, it is said, of equal importance to the previous one, and should, it is suggested, be equal. If, however, stock is good

and the working capital ratio is 2 : 1 or better, the other, in general engineering businesses, should not be taken over-seriously.

The turnover of debtors and creditors should be closely watched, as should stock turnover to volume of business. Investment in work in progress is a ratio which is not given the prominence it deserves, for, in fact, in the majority of engineering works, it tends to be too high. The amount of work in progress in terms of hours of work in the job and the time the job takes to go through the works can be related to works capacity. The fallacy of ratioing work in progress value to turnover and trying to work to this ratio when the material values in work in progress may vary from 2d. to 14d. per pound in general engineering work should be patent.

From year to year the ratio of production equipment investment to volume of business should be observed. Too often one finds a company sharing as profit what should go to replace plant, with bitter results.

The use of such controls as are here mentioned, plus proper cost control from which flows a methodical and clear system of reports to the management, will suffice for financial and cost control of the companies for which this book is written.

CHAPTER XXVII

SALES METHODS

ANALYSIS of sales effectiveness does not always begin in the sales office; indeed, it may and often does start in the drawing office, from which point sales troubles can easily begin. True, one can organize selling effort and selling records and ignore variable quality, poor delivery, lack of up-to-date product research, and wild pricing, but, let it be quite definite, not if the reorganization is an engineered one.

SALES EFFECTIVENESS ANALYSIS

This, as we have said, would start off outside the sales office in most cases and would begin with—

1. Sales development. Complete list of all products, competition with each of these, and competitors' designs and prices.

(In those companies which have not the urge for research and development it is often worth while to list all products against competitors' and *like foreign products* and to compare range of manufactures, sizes, weights, appearance, output range and capacities, ease of operation, accessories supplied, guarantees given, delivery period, and cost. An honest-to-goodness analysis of this sort has put more than one company back on its feet.

Allied to this may be considered the question of sales development of new product supply over, say, the next two to five years. Close customer contact plus an up-to-date home and foreign catalogue and patent file, plus periodical foreign visits backed by a good drawing office will often work wonders to company policy.)

2. Check up costing accuracy on each product, paying special attention to oddments and very special lines. (In

more than one instance the writer has discovered lines running at considerable losses which showed only with proper cost method—Chapter XXIII.)

3. Is there a record of profit or loss on each line run? If so, what does it show?

4. Is there a record of reasons for failure to turn inquiries into orders: delivery, price, design, quality, contacts?

5. Is there a card or other index covering potential buyers and customers? If so, does the card have on it buying power, people to contact, inquiry, follow-up, order, and complaint detail? Are cards so worked that they become live immediately an inquiry is placed or if contact is suspended for too long?

6. Is the mailing list well organized?

7. Is any attempt made to budget (*a*) calls, and (*b*) mailing in terms of buying power?

8. Is sales effort directional? I.e. are the customer and potential customer index so organized and the territories so mapped out that sales contacts by representatives can be directed in most cases by central office?

9. Consider if it is worth while listing all potential and actual customers in one territory and putting against each, where applicable, buying power, inquiries with values, orders, and calls made.

10. Check up territorial sales and inquiries against territorial potentials, calls, and expenses. Include in this any branch offices.

11. Is there a record for each representative covering customer calls, ground-breaking calls, inquiries, sales by products, and expenses? (The "high number of calls" fever must be avoided, as, too, must no control of calls whatsoever.)

12. How are calls reported, and when? How handled into records?

13. On what basis is advertising done? Mailing? Is a

budget made out? Is advertising and mailing a spare-time job for somebody? Is quality good?

SALES REPORTS

Some companies get reports once each week, others get reports once each day; some like reports made out two or more to a sheet, others prefer a sheet per call; some use a printed sheet, others use letterheads, and, occasionally, a company uses one kind of sheet for first calls and another kind of sheet for repeat calls.

In general, the writer has found one report sheet per call most effective. This sheet can be made out immediately after the call is made, thus making overtime unnecessary on the part of the representatives. The report should be so printed that the right kind of information is sent in, and so, too, that representatives' time is saved.

The sales report sheets are usually bound in book form, and reports are in duplicate, the tear-out copy going to central office. Fig. 65 shows a typical report sheet.

For ground-breaking calls it is the writer's opinion that a report sheet which specifically directs the representative's attention to collection of information for office records should be used (see Fig. 68). This information is the basis of the sales index card and of the mailing list. Much tact is required to change representatives over from slip-shod reports; however, one expects much tact in a sales manager.

THE MAJOR SALES RECORD

The kind of record used in the sales office will depend on the kind of products made and the size of the business. That there should be such a record may be taken for granted.

The record may have customer's or potential customer's name and address, telephone number, products made and sold, value of turnover, buyer's, general manager's, works

No. 4001

SALES REPORT

Area. Sub-area Rep..
Prospect: Town·
Call. Contract Complaint: or
Quotations
(1)
Ref :
(2)
Ref.:
(3)
Ref.·
Detail from office record

[*Note all of foregoing data are typed in by central office and sent to representative*]

Date of call Saw/'phoned Mr
and Mr Positions
Quotation needed for tendering ordering
Competitors' offers

Attitude to our offer

Remarks

Signed:

FIG. 65. SALES REPORT

manager's, works engineer's, and, perhaps, chief draughtsman's names, financial status, budgeted calls and mailing (see under Directional Selling, page 254), budgeted sales, and columns for inquiry, order, complaint, and contact detail. A typical card is shown in Fig. 66.

It should be insisted that the record be full and that information be not left off because the card may extend to large dimensions (12 in. × 9 in. is not unusual).

MONTH	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31

No.:	Name:	Town:		Area:	Sub-area:
Chairman:	Man'g Dir.:	G. M.:	W. M.:	C. E.:	P. E.:
C. Insp.:	Buyers: (1)	(2)	(3)	Credit:	Terms:
Products:				Value:	
Budget calls:	Rep.:	Tech'l:	Executive:	Budget Mailing:	
				Code No.:	

Inquiry Detail			Call Dates	Order Detail				Delivery Detail	Dis-patched	Reason for Losing Order	Com-plaints
Date	For	Value		Date	Order No.	For	Value				

FIG. 66. SALES RECORD CARD

REPRESENTATIVE'S RECORD CARD   Month:

Area: Representative: Address: Tel.:

Customers in Area year ended: Year beginning: Budget:

Inquiry Value	Code	Calls	Result	Inquiry Value	Code	Calls	Result	Inquiry Value	Code	Calls	Result	Inquiry Value	Code	Calls	Result	Other Calls

Value of Inquiries: £   Orders: £   Orders Lost: £   Calls: Expense: £

To Date Inquiries: £   Orders: £   Orders Lost: £   Calls: Expense: £

FIG. 67. REPRESENTATIVE'S RECORD CARD

Taking it for the moment that directional selling is not used, the card is operated as follows. All sales reports are passed across the record cards, and calls, dates of calls, and results noted. When an inquiry comes in and a card covers the inquirer, the card becomes live, i.e. it comes out of the territorial file and is signalled to be scanned at a certain date when a representative should report. It stays in the special date file until the order is gained or lost. The card is signalled, also, to show the approximate date of the next personal contact, but, for this purpose, it is kept in the ordinary file.

TERRITORIAL RECORD CARD

The record card mentioned in the previous section covers potential customers and customers, and is filed by territory. In front of each group of cards representing one sales area is kept a territorial record card (Fig. 67).

This record card has on it representative's name, address, and telephone number. Columned information includes value of inquiries, number of calls, value of orders, code telling kind of inquiries and orders, and sales expense. Its uses are obvious, yet very few companies seem to have such a card.

The territorial record card is entered up each morning when the sales record card is filled up.

THE MAILING LIST

Mailing lists are often a hotch-potch of names and addresses loosely collected by scanning technical press advertisements and sales reports. It is the writer's opinion that every name on the mailing list should be covered by a sales record card, for how else is one to know if mail effort is followed up?

One large engineering company spent hundreds of pounds on status research up and down the country with results which fully justified the effort. Other engineering companies

No. 2102

STATUS REPORT

Name of Company:
Address:

PRODUCTS

Name . . Types . . Value each year						

Growth of company: Credit position:
Issued capital: Profits: 19— , 19— , 19—
Chairman: Managing director:
General Man.: Works Man.:
Production Man.: Chief Engineer:
Buyers: (1) (2)
Size of works: Employees:
Company associated with:

We buy from them:
From associates:
Our competitors:
Remarks:

Your suggestion: Mail: Times/year:
Calls: Rep: Tech'l: Executive:
Office summary:

Date:

FIG. 68

should consider something similar for, to be quite frank, in the three score or so instances in which the writer examined sales record and mail lists they were utterly inadequate in more than 75 per cent of cases.

The filing of mailing list address plates depends on the kind of market contacted. It is most usual to file sales record cards by territories and mail list address plates by trades.

DIRECTIONAL SELLING

The advent of directional or planned selling and mailing is an unpleasant business in most companies, for, in every instance, the writer has met with arguments about loss of freedom, loss of initiative, loss of orders, and, of course, the unsuitability of the method for "our peculiarly unique and difficult business." The proof of the pudding is in the eating, and while 100 per cent application of the method is unlikely in any engineering business, it can and may be applied to some extent with good results where full-time representatives are employed.

In short, directional or planned selling aims to have sales effort spent in terms of likely business. Each customer and potential customer is coded for buying power and by sales sub-territory. Sub-territory maps clearly showing contact location and mileage between contacts are used. When the live sales record cards are examined each day they are sorted out in sub-territories; record cards in the ordinary files signalled for calls due are taken out and added to live cards, and a series of sales calls for the day or the week is made out. Minimum travelling is aimed at, and an effort is made to get the representative to start at the farthest point from home and work towards home. Note that inquiries on hand and buying power are the major considerations.

Usually, the sales report forms are typed in the office, and helpful comments about past orders or lack of them,

complaints, who to see, and the like are filled in. These are then sent to the representative.

A book could be written on this and kindred engineering sales matters, but enough has been said here to arouse thought. The main point is: the more the buying power the more the personal contact and the less the mailing, the less the buying power the less the personal contact and the more the mailing.

ADVERTISING AND MAILING

Engineering advertising is one of those subjects severely left alone by current periodicals concerned with advertising. This is not to be wondered at when one considers the vast field of specialist technical knowledge required effectively to cover engineering advertising.

If, however, one has kept closely in touch with technical advertising, certain forward tendencies are observable. The old, heavy black type and little white space advertisements are declining, as is sporadic advertising in favour of consistent effort.

Yet there seems to be a vast difference of opinion among engineers about advertising fundamentals, if there are any such fundamentals.

Some of the bigger companies use "poster advertising," consisting of a large picture and the name and address of the company, with sometimes a product slogan added. This is quite good if buyers know *all about the facts of the product and only require reminders.* There is a slight chance of big companies thinking "poster advertising" and "pretty picture" advertising lends dignity, but does it really sell the product?

Many of the smaller companies (and some of the large ones) lean towards heavy black lines of mere statement about products they make; some even have underlines and stars added. Some others put the company's name in heavy type with, also in heavy type, what is made.

GENERAL RULES

While the writer has neither the space nor the full facts to lay down laws about the best form of engineering advertising, it does seem that the money spent per square inch of space used justifies a little more thought being given to the matter. We all know the general rules—

(*a*) An advertisement should be attractive.

(*b*) It should interest the potential buyer.

(*c*) It should convince him, and

(*d*) It should cause action.

If we apply these rules to the bulk of engineering advertising it seems not to come up to the mark. The best form of engineering advertising is that which attractively advertises one product at a time and which *gives proved reasons* why the product is needed by the potential buyer. There the matter must be left.

Mailing in many engineering companies suffers because—

(*a*) It is not being continually fostered and vitalized as a powerful selling weapon.

(*b*) Letters are poorly laid out and ineffectively written.

(*c*) Mailing is sporadic.

There is, usually, need for continuous revision of the mailing list. Letters should avoid the "we have this," "we are that," and "we will do" tone. The reader is not much interested in any problems and troubles but his own; therefore, "you" and "your" should have prominence. The letters should start off with a fact or about a fact, they should generally be brief, and they should build up to the creation of the right impression or the causing of the right action.

Much improvement has recently been made in methods of mailing letter production. Matching up the address with the body of the letter should be done carefully (a recent machine automatically types the letters), and, if possible, the letter should be signed.

Mailing should as far as is possible be budgeted as to field, time, and expense. Directional mailing is undoubtedly the best.

SALES STATISTICAL CONTROL

Forecasting statistics are among the most interesting in a sales office, and it may be worth while for any but small companies to subscribe to a forecasting service to plot their averaged sales curves against the business forecast line, or any one item included, in an attempt to find a forecast for the particular business.

However, the most pressing need is for ordinary common-sense controls; the following is typical of monthly statistical controls in a well-organized company—

1. Sales for this year and last year by periods and to date.
2. Orders in hand as (1).
3. Inquiries outstanding as (1).
4. Analysis of (1), (2), and (3) by lines and by territory for this and last year by periods and to date.
5. Analysis of orders lost by lines, with reasons.
6. New accounts opened.
7. Sales expense in total and by territory as (1).
8. Sales trend curve for each product and in total on a moving average basis with, say, 12 months as base.

Given these, the sales executive official can work out number of calls, productive and unproductive cost per call, and similar detail. From these particulars he can build up major annual controls.

COST OF SALES

While advertising cost is generally about ¾–1 per cent of sales value, total sales cost may vary between 2 per cent (high value products and contract conditions) and 10 per cent (low value products, non-repetitive); about 6 per cent is average.

There is no universal ratio for sales cost; investment in good management and some directional effort is the soundest policy.

CHAPTER XXVIII

OFFICE METHODS

THE difference between the methods used in the small and the large engineering works is sometimes very startling as, even more so, is the difference in office equipment and conditions. It seems as if the small works has fallen behind in the consideration of modern office organization, but, in some respects, there are sufficient reasons for the seeming backwardness in method.

FACTORS DETERMINING OFFICE METHODS

It is not merely size of company which determines office methods but such direct factors as number of accounts, number of invoices and statements sent out and received, number of employees paid each week, whether or not there is a bonus system, number of letters sent out and received, and similar factors.

It is unfortunate that the factors mentioned above are not always stressed when office mechanisms are being considered. Too often one finds a large company, merely because it is a large company, investing in all kinds of office gadgets which are not justified by the ultimate savings made. On the other hand, one can find companies which are prepared to spend much money in the works but, in the office, will spend little or none, no matter what the justification.

OFFICE EFFECTIVENESS ANALYSIS

Taking the office function as including control of office lay-out and equipment, stores, correspondence, filing, central typing, wage calculation and payment, book-keeping generally, and telephones and telegrams, one may proceed to analyse office effectiveness under such headings.

In our other chapters we have illustrated a straight-through analysis, but so diverse are the duties involved in a general office that it is more suitable to treat both analysis and suggestions under the heading of each of the general office sub-functions.

LAY-OUT

There are various theories of office lay-out, the two most important being those which sponsor the completely open type of office and the departmental or private type, respectively. For the average general engineering company the separate location and departmentalization of typing, telephoning, and book-keeping seems most suitable.

Analysis would cover (1) working room, (2) adequacy of filing and office material stock room, (3) width of aisles, (4) position of desks and equipment in terms of work flow (in the larger office), (5) placement of desks for seating room, (6) placement of files and racks in relationship to users of articles therein, (7) lighting, (8) ventilating and heating.

An obvious next step is to consider (9) standards for desks, files, and chairs in terms of modern practice.

Finally, the question of (10) the lay-out of the supervisors' offices or desks to give maximum personnel control would be considered.

OFFICE STORES

It is only in the large works that serious consideration of office material control is really worth while. In the smaller works, however, one can find faults common to the larger organizations, but, so small are the returns, the stores may well be given only a cursory examination.

Analysis here would cover (1) examination of list of all goods in stock: forms, letterheads, envelopes, carbons, pads, plain and ruled paper, typewriter ribbons, brushes, pencils, pens, rubbers, etc., with special stress on number of types

of each kind of goods stocked (this will often show room for effectiveness increase), and (2) examination of list of people allowed to requisition stores and kind of goods requisitioned by each.

Consideration of these two points will cover the main points of office stock-keeping. In the large office the use of control cards for each main item of stock may be useful, as will the use of a supplies used to period of time ratio.

If requisitions for office supplies are used, these can be closed into the cost accounts and compared with the budget (see Chapter XXVI).

CORRESPONDENCE

It is worth while glancing at the standard of correspondence while on the matter of office analysis. Common faults are—

1. The use of hackneyed phrases: "we beg to remain," "we wish to take this opportunity," "re your favour of even date," "we beg to acknowledge receipt of your esteemed" (we thank you for your letter), "as per your letter," "we hereby beg," "thanking you for past favours and assuring you," "yours to hand," etc.

2. Letters too long (dictation has encouraged this).

3. Too much "we" and "I" and not enough "you" and "your."

4. Lack of clarity.

The use of standard paragraphs (or, if not those, of model paragraphs) may help correspondence effectiveness. After all, there is no virtue in not corresponding effectively.

A detail which may be small but is important is the handling of letters. Where the volume of correspondence is large the use of an envelope-opening machine and of sealing and stamping machines is worth considering.

Finally, the effectiveness of distribution of correspondence should be considered. This includes opening, sorting, time

stamping, and delivery to various departments; speed of distribution is often of prime importance.

FILING

In the business carrying out many transactions a good filing system is a good investment. Common faults in filing method are—

1. Loose filing with consequent loss of documents.
2. Correspondent or customer folders (or letter pockets) packed too full.
3. Ineffective time lag between receipt of documents in filing department and filing of documents.
4. Poor control and follow-up of folders in circulation.
5. Too many inactive folders and inactive documents covering inactive subjects kept in filing cabinets among more active folders and documents.
6. Non-central lay-out of department in relationship to departments using files most frequently.

Often the chief fault lies in lack of recognition by higher management of the importance of filing to the extent of placing a young person in charge, when, for a few shillings extra each week, the job could be done so much better. This would not happen if it were remembered that the most immediate test of filing effectiveness is not, what does the filing department cost? but, how does its operation aid or hinder the work of other departments?

TYPING

The argument on the merits of completely centralized and partially centralized typing is as old as typing itself yet as fresh as ever. The trouble is that when one discusses it with others, delicate matters of personal prestige enter into the discussion for, alas, we most of us like a private office and a special typist all to ourselves. Often we argue the

very special nature of our work when, in fact, we delude ourselves.

From the cost standpoint, centralized typing is most effective, and, with this, there is no reason why each chief executive should not have his special typist.

Perhaps the most illuminating analysis of typing effectiveness can be made through the use of log sheets and record sheets. The log sheet, one for each day, is kept by the typist, who enters thereon all her comings, goings, and workings, and the record sheet is kept by the typing supervisor who notes each day the kinds of typing done and the square inches of type for each typist. This, if run for a week, will as likely indicate the need for various executive officials pulling their socks up, as for the typists doing the same with their stockings!

Such an analysis as the foregoing should precede investments in dictating machines, electric typewriters, and, last but not least, bonus systems for typing output.

TIME RECORDS AND WAGE CALCULATION

In the small business having round about fifty people there are, no doubt, quite good reasons for the use of the handwritten wage sheet columned for days of the week, daywork wage, piecework earnings, and totals. In larger businesses, however, the use of book-keeping machines for this purpose is more economical and more accurate, as is the use of addressing machines in place of handwriting for production of time cards and pay envelopes.

The use of a calculating machine for wage and cost computation is essential in nearly every office. On certain types of these machines such a wage sheet as is shown in Fig. 69 can mechanically be posted and totalled.

Where the usual time and job cards are used the transcribing of information therefrom may, as mentioned above, be mechanized by the aid of keyboard calculating machines.

Check No.	Company Insurance Sick U.E.	Gross Wages	Bank	Thrift Club	Employer Insurance Sick U.E.	Net Wages

FIG. 69. WAGES SHEET

The use of a tabulating machine card (Fig. 70) makes very rapid the calculating and posting of wages, and, using the same card, the getting out of costs. With this method everything is numeralized; man's number, time, overheads, department job number, wage, machine number, and the like. The information written on the card is punched by machine, mechanically sorted into any specified combination on another machine, and, finally, tabulated by the tabulating machine. This method is well adapted, also, to the distribution of wages and expenses by departments. The same type of card may be used for materials costing.

BOOK-KEEPING METHODS

To many engineering executive officials book-keeping is a mysterious business. This is a pity, for, in fact, a broad knowledge of its methods and a good knowledge of its meanings are of prime value.

The various book-keeping essentials may be taken in their order for purpose of analysis—

1. The purchases are sometimes entered up by hand in an analysed Purchases Day Book. In practice, the invoice (or a copy thereof) may be filed in date order and so coded

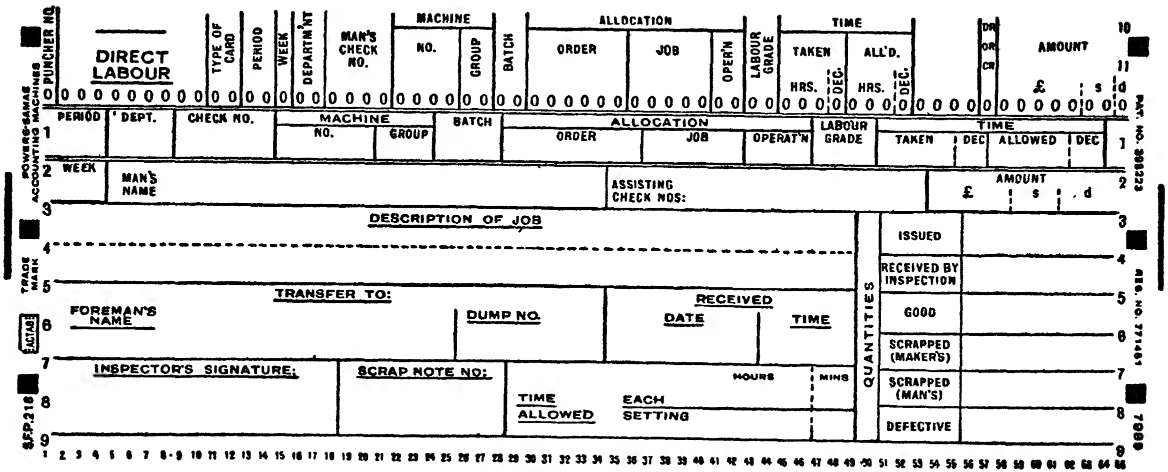


Fig. 70 Tabulating Machine Card

as to department product or type of expense that periodical analysis by calculating machine gives accurate totals.

2. Sales may similarly be treated, the code in this case covering product and territory.

3. For cash or cheques received it is not unusual to find companies with bound Cash Books which are entered by hand, as are receipts and paying-in slips. The use of a loose-leaf Cash Book makes possible the writing up of the Cash Book and the making out of the paying-in slip and the receipt a one operation job on a typewriter adapted for the purpose.

4. For companies paying out a large number of cheques the usual hand-posted Cash Book may be replaced by copy cheques suitably listed.

5. The hand-posted Sales Ledger and the typed statement (handwritten in some instances) may by the use of a card ledger be typed simultaneously. With calculating attachments to the typewriter or with a book-keeping machine the necessary calculations may be mechanized and proved.

The foregoing fairly well covers the book-keeping essentials in the average engineering company. It will be noted that such methods as are mentioned require that the skill be taken out of book-keeping and that the work be largely routine and automatic.

COST OF OFFICE

Where an office can be mechanized and two-thirds female labour used, a fair book-keeping and secretarial salary-turnover ratio (typing, costs and wages excluded) is £100 : £65,000. £100 : £45,000 is a nearer average. Supervision cost is not included.

Typing ratios are valueless. Fair typing allowances are: dictaphone typing, 0·3 min. per sq. in., shorthand typing, 0·5 min. per sq. in.—single spacing; start and end of letter, one carbon, 2 min.; envelopes, 1 min. All at machine.

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